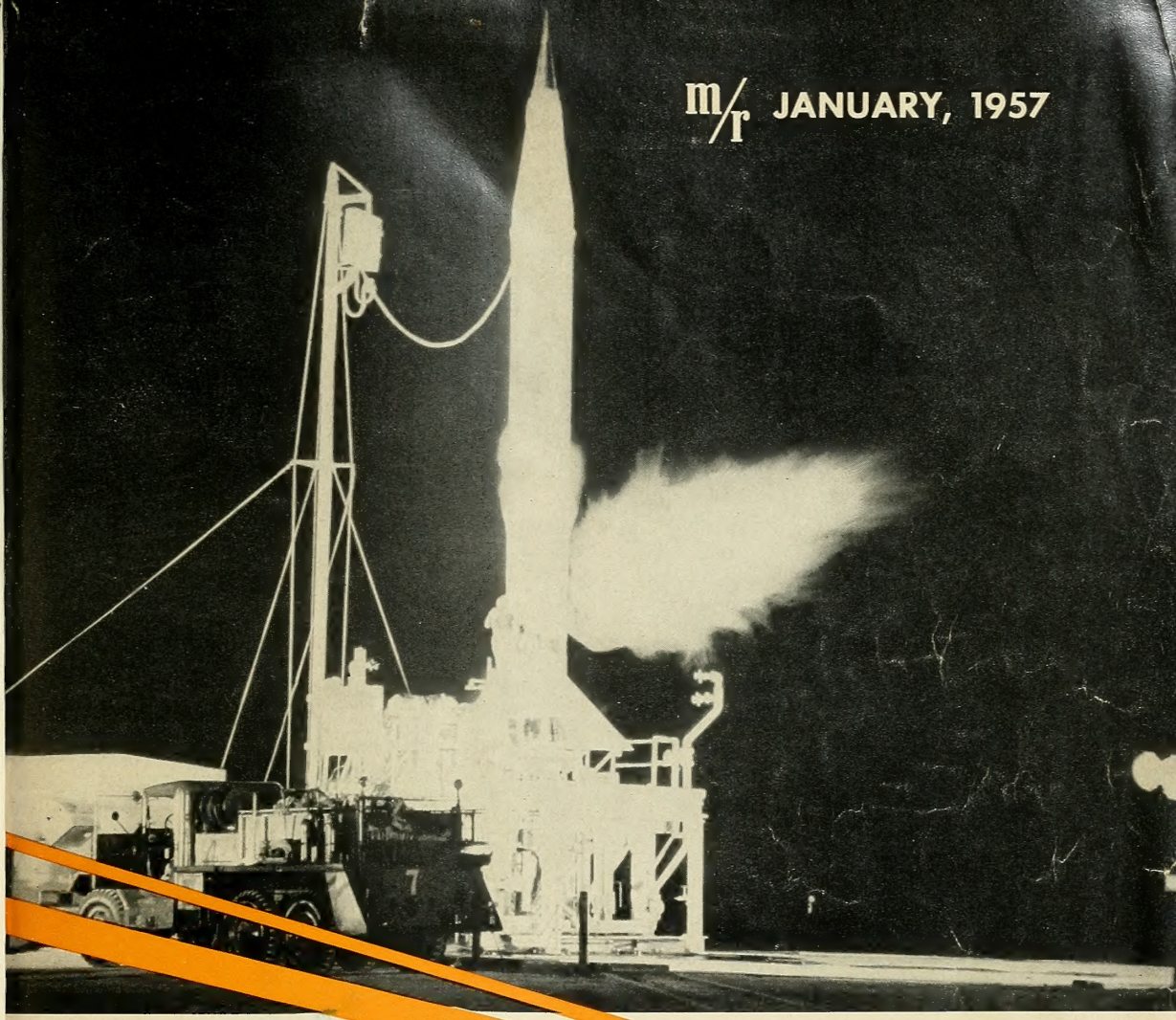
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MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

In This Issue:

U.S. NAVY MISSILE POWER AND SATELLITE PROGRESS

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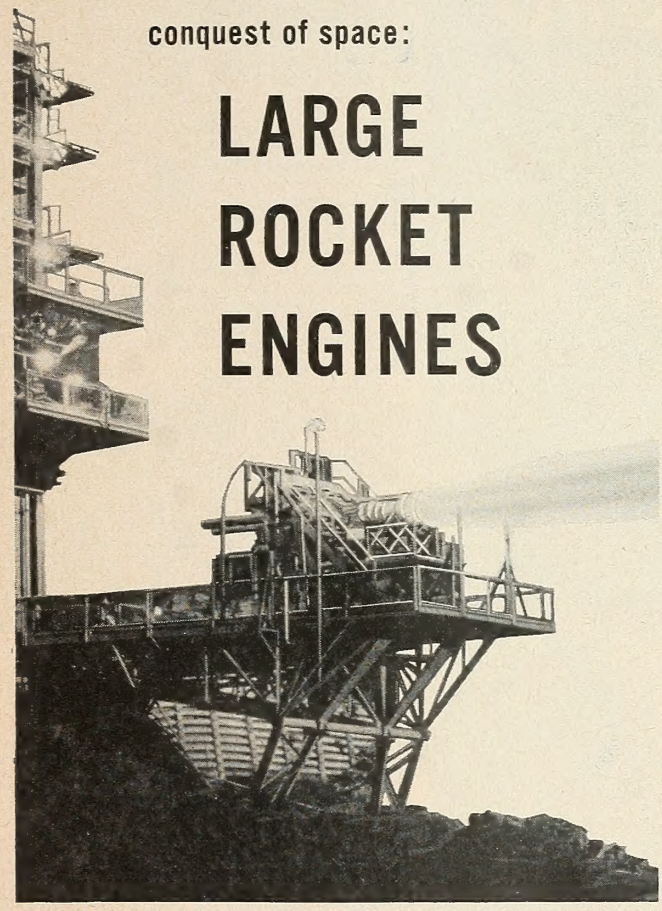
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WILLIAM J. CECKA, JR., 35, aeronautical engineer, (Univ. of Minn. '43), was called from North American by the Air Force for experimental rocket work in 1944. On his return, he progressed rapidly: 1948, supervisory test job; 1950, group engineer, operations; 1953 engineering group leader; 1955, section chief of engineering test. Using our refund plan, he has his M.Sc. in sight.



GEORGE P. SUTTON, in the 13 brilliant years since receiving his MSME, Cal Tech, has made rocketry a way of life. His reputation is world wide. His book *Rocket Propulsion Elements* is recognized as the standard text on the subject. Still active academically, but no bookworm, he takes time off occasionally to study the laws of motion at some of the world's better ski resorts.

Tomorrow's count down already fills the air at ROCKETDYNE'S 1,600-acre Field Test Laboratory in the Santa Susana Mountains near Los Angeles. For this is the free world's largest workshop for rocket engineering—the great new industry that is now attracting many of the finest scientific and engineering minds in the country.

EXACTING RESEARCH, EXCITING PROSPECTS

From the rock-bedded test stands come 2 miles of recordings per day—data far ahead of available texts. The big rocket engine is a flying chemical factory in an absolute state of automation. It tolerates no error. It demands ductwork, turbomachinery, pressure chambers, orifices, injectors, heat exchangers and closed-loop control systems that must put hundreds of pounds of precisely mixed propellants into controlled combustion every second. Tolerances go down to 0.0001″. Temperatures range from -250° F to 5000° F. Process time constants occur in "steady state conditions" of the order of a few milliseconds. Event sequences are minutely evaluated, as basis of designed performance predictions of extreme exactitude.

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INTERESTING BOOKLET: "The Big Challenge"—facts on design criteria and development approaches used at ROCKETDYNE. Write for your personal copy, specifying your degree and years of post-college experience. Address: A. W. Jamieson, Engineering Personnel Dept. MAR, 6633 Canoga Ave., Canoga Park, California.

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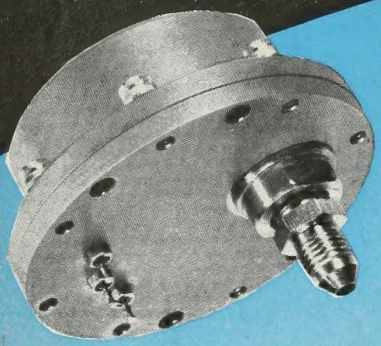
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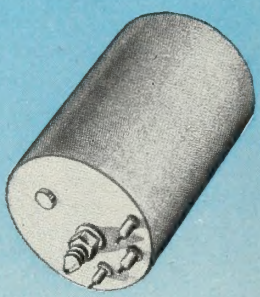
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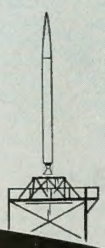


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Magazine of World Astronautics

January, 1957 Volume II, No. 1

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To engineers interested in entering the field of

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E. V. Stearns (left), head of the Inertial Guidance Department, discusses navigation systems mechanization with Inertial Guidance Scientist R. L. McKenzie (center) and Senior Electronics Scientist D. G. Peterson.

Here is a field whose potential is equalled by the magnitude of its problems. The development of components with extraordinary precision alone offers unmatched scope for achievement.

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- **Physics**
- **Electronics (such as magnetic amplifiers)**
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Engineers and scientists possessing experience or keen interest in advanced applications of inertial guidance are invited to write.

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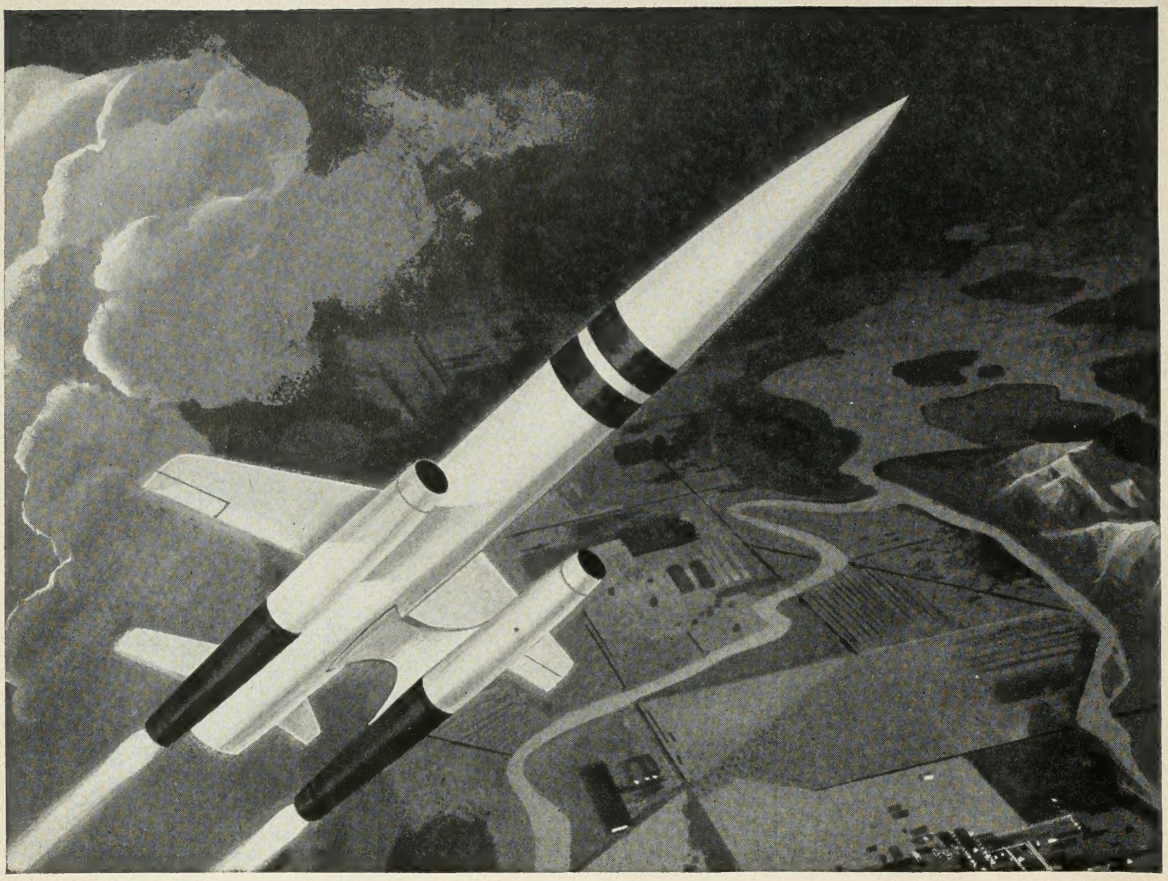
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Lightweight structural metals with high strength, stiffness and elasticity at elevated temperatures! A new group of Dow magnesium alloys offers a great combination of these properties without the fabricating difficulties normally experienced with other high temperature materials.

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FABRICATION: Fabrication characteristics are equal to those of standard magnesium alloys.

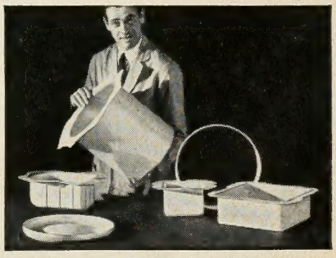
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For more information about the new high temperature magnesium alloys, contact your nearest Dow Sales Office or write to THE DOW CHEMICAL COMPANY, Magnesium Sales Department Midland, Michigan.



EASILY FORMED. These HK31A parts were drawn using production dies and processes for standard magnesium alloys. The parts retained a higher percentage of original properties than standard alloys.

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missiles and rockets

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For the Orphaned ABMA --Independence!

The most experienced ballistic missile research and development group in the world is hanging in the balance.

By an extraordinary stroke of irony, Defense Secretary Wilson's controversial memorandum on missile assignments has orphaned the Army Ballistic Missile Agency.

If by any unlikely chance there is any doubt about the value of ABMA, let the record state that this is the group headed by the talented Wernher von Braun. Let the record show that ABMA is without peer in the world among research or military organizations in its experience in ballistic missile development.

Now that Secretary Wilson has decreed that the Army should have nothing to do with long range ballistic missiles, what is to become of ABMA?

The Navy well may provide the answer. In an exclusive interview in this issue of m/r, with Assistant Secretary of the Navy for Air, Garrison Norton, a gratifying statement occurs: The Navy hopes to make the fullest possible use of ABMA. This is in spite of the fact that the Army and the Navy now are going in separate directions for development of intermediate range ballistic missiles.

We commend the Navy for its foresightedness. Although the technological requirement for a fleet ballistic missile is somewhat different than for the Army's long range ballistic missile, the fact remains that 1200-mile or 1500-mile range ballistic rockets must be based on one and the same design concept.

We think the best solution to the ABMA problem, however, would be to establish this talented group as a separate and independent *national ballistic missile research agency*, somewhat similar in scope to the highly successful National Advisory Committee for Aeronautics.

Meanwhile, the furor over the Wilson memorandum is far from over. It is gaining momentum now that Congress has convened with a number of Senators and Congressmen insisting upon a full-scale review of the Wilson action. There will be a strong demand, based both on the Army's proven record of achievement and on definitions of weapons in tomorrow's world, that the Army be permitted the right to incorporate intermediate range ballistic missiles in its weapon arsenal.

The immediate problem is to save the ABMA team whose morale is understandably at a very low point. At a time when our ballistic missile race is on in the world arena, it is tragic that ABMA is a victim (temporarily, at least) of inter-service competition and squabbles.

WAYNE W. PARRISH.

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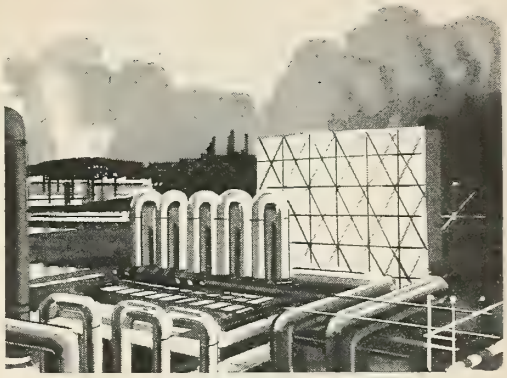
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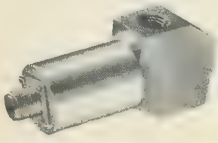
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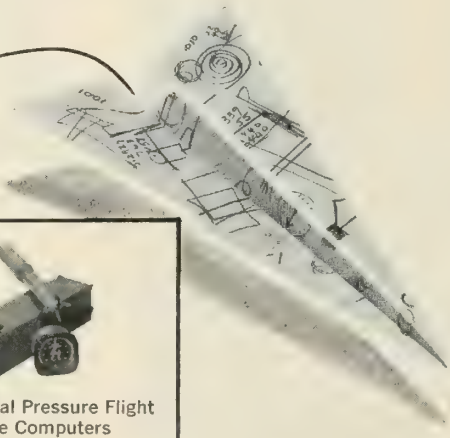
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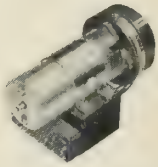
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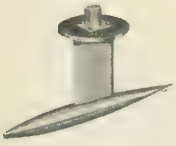


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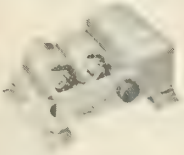
Accelerometers



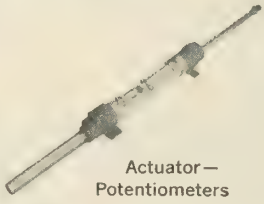
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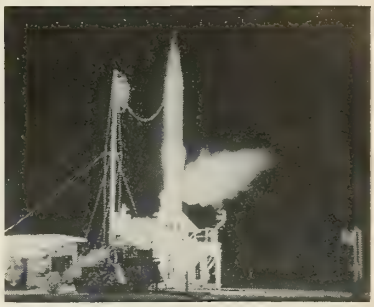
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next issue:

ROCKETRY AND ASTRONAUTICS BEHIND THE IRON CURTAIN.

cover picture:



M/R's cover shows Viking 13 just before it was fired last month from Patrick AFB. The Navy research rocket plays an important part in the step-by-step approach to Project Vanguard and the artificial earth satellite that is to be placed in its orbit during the International Geophysical Year. The white flare-out from the missile is oxygen bleeding off, signaling that the fuel tanks have been topped and that the missile is ready to go.

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Third National Symposium of Reliability and Quality Control in Electronics, sponsored by IRE, AIEE, RETMA, and ASQC, Wash., D. C., Jan. 14-15.

SAE Annual Meeting and Engineering Display, Detroit, Mich., Jan. 14-18.

American Society for Metals, Albuquerque and Los Alamos Chapters, "Heat Tolerant Metals for Aerodynamic Applications," Albuquerque, N. M., Jan. 27-28.

Symposium on Microwave Ferrite Devices & Applications, sponsored by IRE, Engineering Societies Bldg., New York City, Jan. 28-29.

Eighth Annual Plant Maintenance Show, Public Aud., Cleveland, Ohio, Jan. 28-31.

Institute of the Aeronautical Sciences' 25th annual meeting, Sheraton Astor Hotel, New York City, Jan. 28-Feb. 1.

FEBRUARY

Instrument Society of America, Aeronautical Div. of New York Section, mid-winter conference, Garden City, L. I., Feb. 7.

IRE Operations Research Symposium, University of Pa., Museum Lecture Hall, Phila., Pa., Feb. 7.

AFA Jet Age Conference, Sheraton-Park Hotel, Wash., D. C., Feb. 14-15.

Conference on Transistor Circuits, sponsored by IRE, AIEE, Phila., Pa., Feb. 14-15.

Joint Military-Industrial Guided Missile Electronic Test Instrument Symposium, Redstone Arsenal, Huntsville, Ala., Feb. 26-28.

Western Joint Computer Conference, sponsored by IRE, AIEE and ACM, Hotel Statler, Los Angeles, Feb. 26-28.

MARCH

Nat'l Conference on Aviation Education, Mayflower Hotel, Wash., D. C., Mar. 7-9.

Nuclear Congress and Int'l Exposition, Phila., Pa., Mar. 11-15.

IAS Flight Propulsion Mtg. (classified), Cleveland, Ohio, Mar. 14-15.

IRE National Convention, Waldorf Astoria Hotel and New York Coliseum, New York City, Mar. 18-21.

151st National Meeting of the American Meteorological Society, University of Chicago, Mar. 19-21.

American Society of Tool Engineers, Silver Anniversary annual meeting, Shamrock Hilton Hotel, Houston, Tex., Mar. 25-27.

10th Western Metal Exposition & Congress, American Society for Metals and others, Ambassador Hotel and Pan-Pacific Auditorium, Los Angeles, Mar. 25-29.

Educational Colloquium on Radiation Effects on Materials, sponsored by ONR and Glenn L. Martin Co., Johns-Hopkins University, Baltimore, Md., Mar. 27-29.

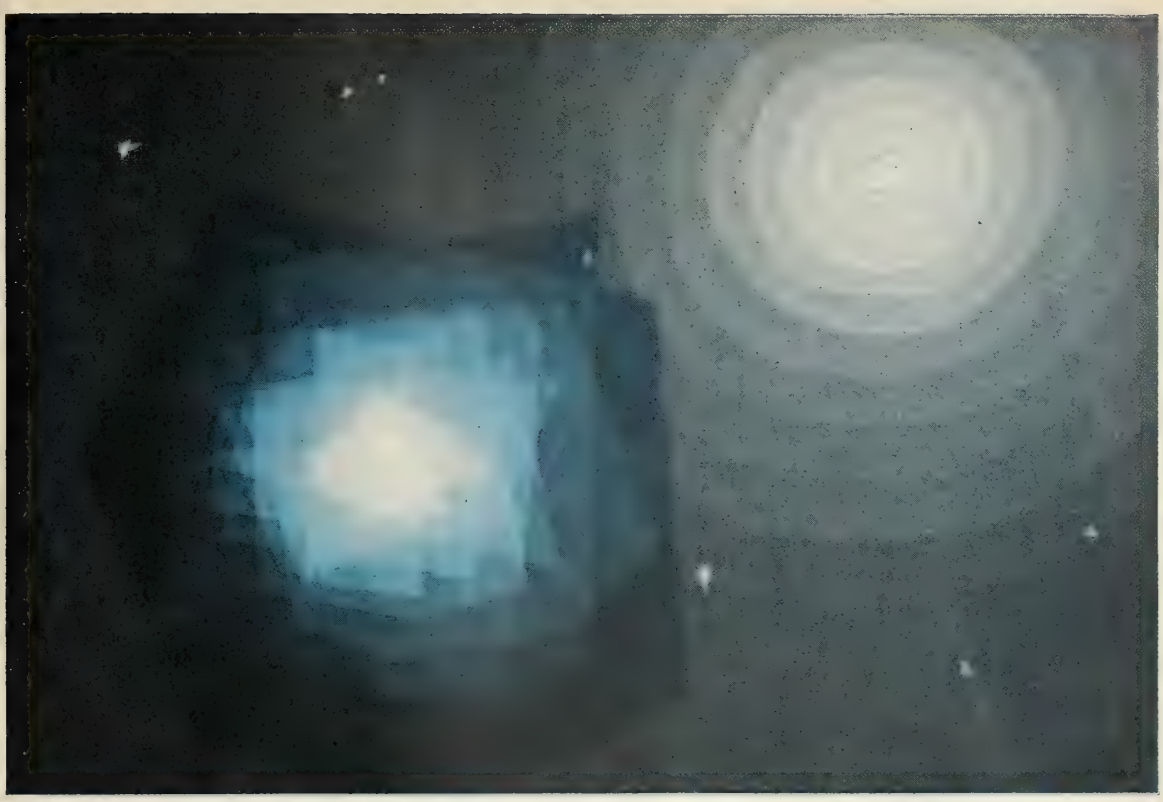
APRIL

SAE Aeronautic Meeting and Production Forum, New York City, Apr. 2-5.

Spring meeting, American Rocket Society, Sheraton-Park Hotel, Wash., D. C., Apr. 3-6.

British Radio and Electronic Component Show, Grosvenor House and Park Lane House, London, England, Apr. 8-11.

IRE PGTRC National Symposium on Telemetering, Phila., Pa., Apr. 14-16.



"EARTH" one of a series of paintings of the planets by Simpson-Middleman, painters who have been finding their subject matter in science. To quote them: "Earth is distinguished among the planets by its oceans of water and its single moon. From these as a starting point, Earth in this painting has been imagined as a configuration of intersecting planes—layer on layer of blue—until it becomes a transparent crystal, glowing in space." Painting courtesy John Heller Gallery, Inc.

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BOEING

letters

Satellite Orbit Still Questioned

To the editor:

. . . Thank you for publishing my letter, SATELLITE VS. EARTH ROTATION, p. 18, December 1956 issue MISSILE & ROCKETS, with the NRL comment. Rather than debate the question on theoretical grounds, permit me to offer familiar empirical proof.

If two boys position themselves 100 feet apart on the parade ground at Patrick AFB (Cape Carnaveral, Florida) on a north-south line, and one throws a ball into the air toward the other, the ball will be (neglecting atmospheric friction) in a free orbit just as will the satellite (although a very elliptical one which intersects the surface of the earth). If the earth "turns beneath it" while in orbit, the ball would promptly disappear to the west at some 900 miles per hour upon leaving the boy's hand; if thrown so as to remain in the air for four seconds, it would fall to the ground one mile away! Obviously the ball—and the satellite—will retain the eastward motion which it had while resting on the surface, and into whatever orbit it is dispatched, will return to the same point on the surface of the earth from which it was launched, whatever motion this point has in space. In doing so, the plane of the orbits must rotate with the rotating earth.

This argument appears to have been anticipated in only one public exposition of Vanguard motion: on page 495, April 1956 issue of NATIONAL GEOGRAPHIC MAGAZINE the following statement is made: "Any object in the grip of the air follows earth's rotation—approximately 1,000 miles per hour at the Equator. But a man-made satellite beyond the atmosphere, like the moon itself, will remain independent of earth's spin." If this idea that a satellite at 300 miles altitude will behave differently than a "satellite" baseball at 50 feet because the latter is "in the grip of the atmosphere" is taken seriously by anyone, let him disprove it by recreating the baseball experiment in miniature without the presence of an atmosphere, i.e., with a lead pellet in an evacuated bell jar. I assure him that the pellet will not crash through the west side of the jar with the speed of a rifle bullet!

Various secondary corrections have been prepared for the calculations as published in the latter part of my December letter; a limited number of copies are available upon request . . .

Charles C. Littell, Jr.
Engineering Associates
434 Patterson Rd.
Dayton 9, Ohio

Battery Output Discussion

To the editor:

. . . I have recently had an opportunity to look through your December 1956 issue of MISSILES & ROCKETS.

Three citations taken from this issue illustrate the difficulty of getting correct information these days. I refer to the figures given for energy outputs for dry cells in connection with missile operations. On page 82 Dr. S. Fred Singer includes tabular material which shows dry cells as giving out 14 watt hours per pound. Turning now to page 103, Mr. Henry P. Steier gives a figure of 50 watt hours per pound for dry cells. Finally, in his article on a case for reliable missile batteries, Joseph S. Murphy cites figures on page 112 which give four watt hours per pound for common dry cells. Obviously, there must be additional factors in all these cases which are not reflected in the text material.

While I do not expect that you have answers to this question immediately, it might be worth a small amount of research to clarify the matter . . .

J. W. Joyce
6641 32nd Street, N. W.
Washington 15, D. C.

P. R. Mallory & Co., large producer of batteries, points out rate of discharge should be part of statements on battery power per unit of weight. The company says 40-50 watt-hours/lb at 20 hour rate is correct for mercuric oxide batteries. For zinc-carbon batteries figure could run down to 4 watt-hours/lb at high discharge rate. Editor Steier was referring to mercury cells. Editor Murphy gave figures related to "missile discharge rates." ed.

More Talk About m/r

To the editor:

. . . Your office must be perpetually flooded with complimentary letters these days, if only a small fraction of your readers write to tell you that they think, as I do, that your publication is most literally tops. Again, my heartiest congratulations. The December issue of MISSILES & ROCKETS arrived this morning and I have heard more talk about it among our scientists, engineers and technicians than about any of the many other magazines our people read . . .

Bliss K. Thorne
Public Relations Director
Avco Research and Advanced Development Division
20 South Union Street
Lawrence, Massachusetts

Another Contractor For Mighty Mouse

To the editor:

. . . We were very much interested to read the article "U.S. Aircraft Rockets—How Good?" on pages 13-14-15 of your November issue, regarding the 2.75 Mighty Mouse Rocket.

However, on page 14, we were somewhat disturbed to read the information "the only three principal contractors slated to remain in the program according to the Navy are Aerojet-General Corp., Azusa, California; Hunter Douglas Aluminum Co., Riverside, California; Heintz Manufacturing Co., Philadelphia."

The Colson Corporation received the *only* contract which was awarded in November 1955 for "the rocket motor and ingenious folding fin assembly." This was for production in early 1956 which was not completed until early fall. Aerojet General Corporation received a contract, I believe in August 1956, for production in 1957.

A contract has just been awarded to the Colson Corporation for production of rocket motor assembly for 1957 . . .

J. M. Spooner
Director of Marketing
The Colson Corporation
Elyria, Ohio

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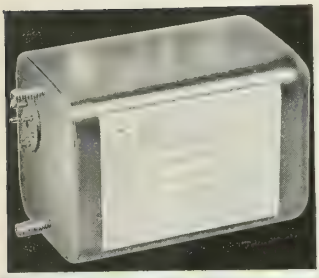


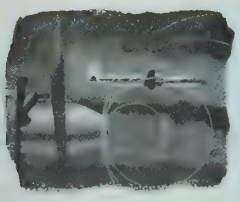
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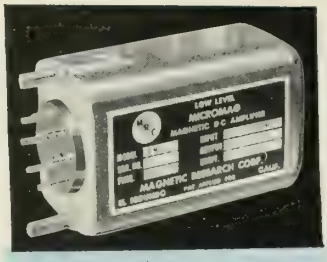


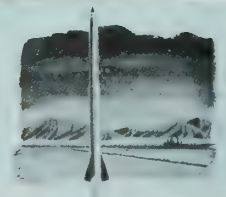


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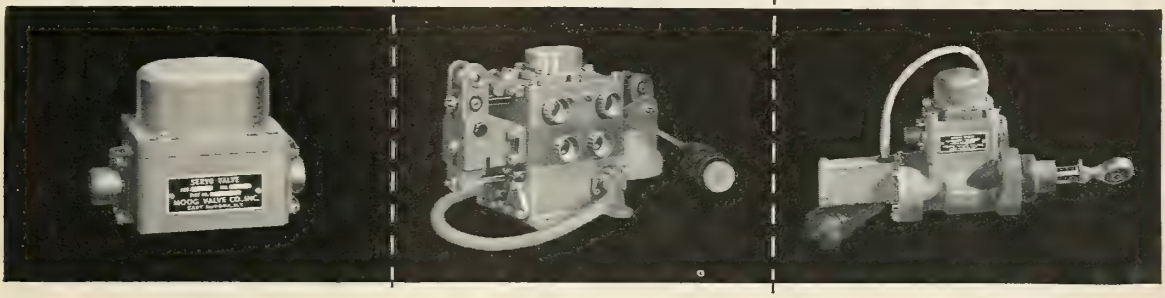
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Break-up in Army-Navy *Jupiter* Program

Polaris Fleet Ballistic Missile Project Started; Nuclear Missile Submarines Part of Program

By Erik Bergaust

The world's newest and most sophisticated underwater vessels are being planned by top Navy officials in the Pentagon. Needless to say, these submarines are nuclear-powered guided missile carriers. And they will be built to launch the solid-propellant, high-punch, intermediate-range *Polaris* Fleet Ballistic Missile.

The submarines—possibly two prototypes on order at first—are part of the *Polaris* project, which has just been confirmed to m/r by Assistant Secretary of the Navy for Air, Garrison Norton (see page 43).

Possibly the biggest missile and most complex weapons system the Navy has ever attempted, the *Polaris* will be a high-energy solid-propellant stubby 40-50-foot missile approximately 100 inches in diameter. Range is believed to be better than 800 miles. The atomic warhead in the *Polaris* will be quite sizeable, 1,000 pounds might be a fair guess. Most interesting fact about the *Polaris*, however, is that it will be a jelly- or solid-propellant rocket designed to be launched from submerged submarines as well as from surface vessels or surface installations.

Both liquid and solid-propellant rockets can be fired from underwater. But handling of liquid propellants at sea (or land, for that matter) involves several hazards that the Navy doesn't care for too much. And in view of recent progress in the field of high-energy solid propellants the Navy has pulled away from the joint Army/Navy *Jupiter* program and set out to develop its own intermediate-range guided rocket.

The Army's remarkable ballistic rocket team under the direction of Dr. Wernher von Braun is understood to have helped the Navy create this fabulous weapon. As a matter of fact, members of this team built underwater solid rockets 13 years ago. They mounted a launching rack holding six solid-propellant rockets on the deck of a submarine. From as deep as 100 feet the stubby *Borsig* rockets zoomed to the surface at an angle of 45 degrees and then streaked aloft into the blue skies over Peenemunde. The German Admiralty turned the weapons system down—because it was developed for them by a competing service—the Army.

Nevertheless, the technical reports on underwater-launched missiles have been available in this country ever since Dr. Wernher von Braun and his missile team came to the United States. Not until recently, however, did our own Navy realize the potentials that this principle offers.

Liquid-propellant sub missiles also have been studied in recent years. Such missiles must be placed inside a container or watertight shell.

Once the vehicle pops out of the water, the outer shell or container will throw away the nose cone, and the actual missile will roar aloft without having been in touch with water, and leaving the container behind. Because of the buoyancy the missile might ascend in a straight line to the surface and take off vertically.

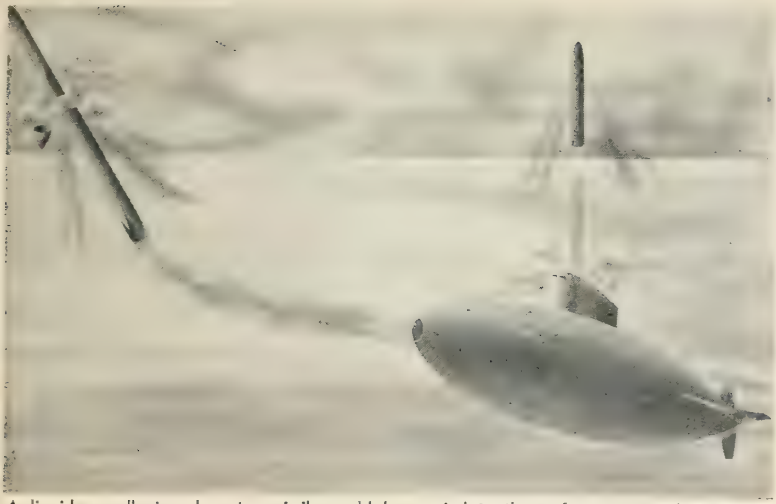
Fueling of a liquid propellant submarine missile must take place at dockside before the sub sets out on its mission, and the art of keeping liquid fuel vaporization at a minimum—and keeping liquid oxygen at the required minus 297 degrees Fahrenheit—is tricky, indeed. Secondly, the underwater missile container adds to the complexity of the system.

While our liquid-propellant rockets are more efficient than solid units—pound for pound, and sizewise, the solid-propellant underwater rocket has many advantages.

The solid rocket doesn't require the outer shell or container. It doesn't require the propellant insulation gear, nor any additional booster or torpedo-type powerplant. Pressurization requirement is insignificant.

Russia Has Polaris-type Rockets

Russia is understood to have developed solid-propellant 650-mile rockets already. These missiles can be launched from submarines; they can also be fired from land installations. Reports say these rockets already make up part of the Russian military set-up in Europe. Alfred J. Zaehringer, m/r Propulsion Editor, and recognized solid-propellant expert, says the Russians have advanced rapidly in the field of Powder rockets, as a matter of fact, Zaehringer says, Russia has put more emphasis on solid rather than on liquid propellants. This means Russian ballistic rockets are larger in size—and possibly clumsy to handle—but their fire power and efficiency must not be underestimated. A round-up on Russian rocketry, including their efforts in the field of solids, will be presented in the February issue of m/r.



A liquid-propellant underwater missile could be carried to the surface in torpedo-type container. Both solid and liquid rockets could be launched this way, but . . .

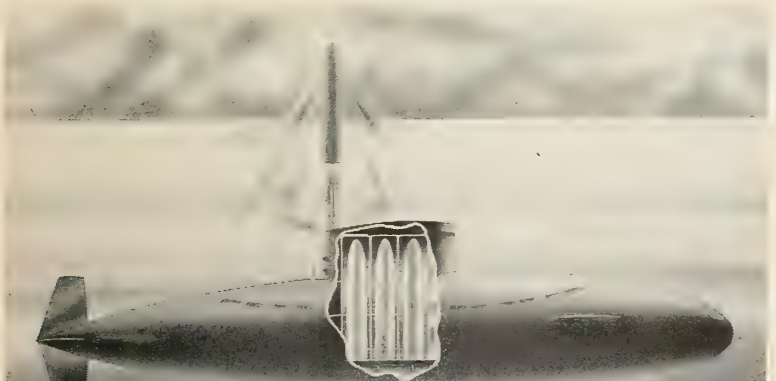
Furthermore, because of the water resistance, a missile moves rather slowly under water. It burns only a small amount of propellants before popping out of the sea; the water back pressure on the combustion holds the burning back.

So the Navy picked the solid-propellant version. And, of course, this missile may be launched from surface vessels as well; from cruisers, battleships and carriers, and from any beach head. The range, however, will probably be considerably less than if liquid propellants were employed.

Missiles Systems Division of Lockheed Aircraft Corporation is to build the *Polaris*. Aerojet-General Corporation will be responsible for the propulsion system, and General Electric and Massachusetts Institute of Technology will be in charge of guidance and fire control.

The submarines must necessarily be large, and since the advantage of this weapons system lies in the fact that the ships may hide off an enemy's coast for months, they are to be fitted with nuclear powerplants. The first atomic powered *Polaris* sub probably will slide down the ways in 1961-2. A whole fleet of them could be available by 1965. It is understood that the *Polaris* subs will employ the *Albacore* fast hull, giving the vessels a speed of about 50 knots underwater.

Unofficial reports from Russia have hinted that the Soviets have developed their submarine missiles to the point where the 600-unit Red submarine fleet now is in position to launch deadly underwater missiles over distances of 650 miles or more from submerged positions and close to 1,500 miles from surface positions.



. . . storage problem probably will determine launching technique to be employed. Polaris sub-carrier supposedly will be blimp-shaped like the U.S.S. Albacore.

Scientists Discuss Mars Observation

Extensive astronomical observations of Mars during its close approach late last summer and early fall formed the basis for a recent symposium held jointly by the American Astronomical Society and the American Association for the Advancement of Science in New York City. Conferees pointed out much work still had to be done before a full assessment of the close approach of Mars could be made. The international Mars committee, with headquarters at Lowell Observatory, Flagstaff, Arizona, coordinated the various phases of the close approach. Participants promised that reports on the occasion would be forthcoming.

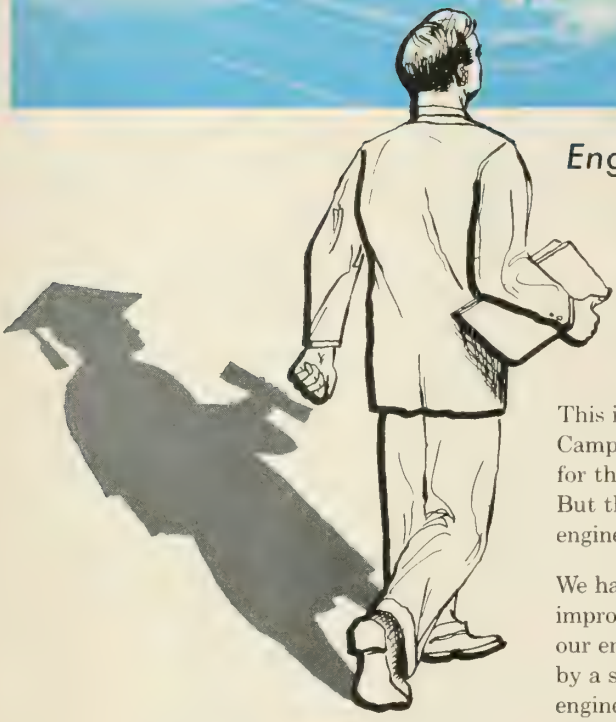
Chairman of the symposium was Fred L. Whipple, Director of the Harvard Observatory. Participants included G. P. Kuiper of McDonald Observatory, Seth B. Nickolson (speaking for R. S. Richardson) of Palomar-Mt. Wilson Observatories, S. L. Hess of Florida State University and Lowell Observatory, C. C. Kiess of the U.S. Bureau of Standards, and C. H. Meyer of the Naval Research Laboratory. In addition to the papers presented at the symposium, two other Mars reports were given during the four-day AAS session, one by W. N. Sinton of Harvard Observatory on "A Spectroscopic Search for Vegetation on Mars," and one by S. L. Hess entitled "Blue Haze and the Vertical Structure of the Martian Atmosphere."

The color of Mars drew some attention during the symposium. Polarcaps are probably almost pure white, with perhaps a faint tinge of ivory. Investigation of the color of the desert areas have been made. Dark ochre to red yellow are characteristically reported when the planet is submerged into red light, but large contrasts are common. Possible tie-ins between the characteristics of the atmosphere and surface colorings were mentioned. Dr. Kuiper, for example, suggested that the "canals" may be streaks, caused by varying albedos.

The possibility that the dark areas are essentially lava fields, perhaps partially covered with some sort of vegetation, was introduced.

Periodic color changes might be caused by dust settling on these fields, only to be subsequently blown away. Dr. Kuiper's studies also covered the oblateness of Mars, tidal friction effects on Phobos (one of its moons) and infrared investigations.





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US Air Force To Begin ICBM Training

Air Force will introduce long-range ballistic missile capability into the strategic Air Command late in fiscal 1958, according to present plans. While the plans do not encompass actual operational wings, they do provide for acquisition of sufficient hardware on which to start an intensive training program. First construction on ICBM batteries may also take place.

Under the present timetable, ICBM missile wings will be integrated into SAC within the next five years. Fiscal 1958 training on hardware will be carried out at Western Development Command's newly acquired Camp Cooke, Calif., site, as well as at SAC itself. Personnel will be indoctrinated on components, assembly, parts identification, fueling, etc.

The missile wings will be similar in composition to the heavy SAC bomber wings. First missile wings will not, it has been strongly asserted, replace the bombers. They will initially be used as an adjunct in a program to determine where missiles properly fit in the SAC mission picture. It is now estimated that missile wings probably will have to be manned by more than the 3,000 personnel now attached to heavy bomber wings.

Missile battery sites will be located according to a dispersal plan but in proximity to SAC bases, which will provide necessary support.

The plan ties in closely with upcoming considerations on the Defense Budget. In budget research and development requests both President Eisenhower and Defense Secretary Wilson have put an untouchable priority on ICBM *Titan* and *Atlas* projects. Other projects have been robbed to fulfill the order, including *Navaho*.

Reliable sources have revealed that the ICBM is now close to the same time schedule as the older *Navaho* project. *Navaho*, however, which boasts a more accurate guidance system, will be kept in tact. AF is not overlooking the possibility that bugs may develop in ICBM testing and that *Navaho* will then become more attractive.

But as the budget now stands, pessimism prevails as to *Navaho's* production future. AF will go down fighting, however, to preserve its status and retain it as a research missile if it cannot get a big enough budget to support both.

Maximum effort will be directed in the coming months to pulling the ICBM programs forward to the point of production for training. One top official noted: "We won't see missiles standing on gantries in fiscal 1958, but we will need some for training to establish count-down procedures and so forth."

The admittedly optimistic timeschedule is felt to be mandatory to get the missile capability out of the talking stage.

The Convair *Atlas* was recently described by the British magazine *Flight* as a vehicle standing about 100 feet in height and weighing about 90,000 ibs., presumably empty. The periodical described the *Atlas* as a single-stage missile employing a liquid-propellant sustainer motor of 135,000 lbs. thrust plus two booster motors of 100,000 lbs. thrust each mounted in jettisonable nacelles at the base of the rocket. It is further understood that the *Atlas* prototype is now being assembled at Patrick AFB, Fla., for firing sometime this year.

While the *Navaho* can carry a heavier warhead than its ballistic competitors, this feature is no longer of much significance in view of the appalling energy yield of modern thermonuclear explosives. But it does have the advantage of greater accuracy in guidance since it theoretically can be controlled all the way to target. For this reason, the AF believes it has a place in the combat inventory alongside ICBM—provided sufficient funds are available, but economy will dictate the final solution.

In the Age of Missiles and Rockets

It may be Delphic that a national toy catalogue lists bows and arrows immediately after atomic submarines, electronic ray guns and Inter-Continental Missiles. But be that as it may, in the toyland world of children, the age of tomorrow is here today.

Almost every electronic, supersonic and remote controlled vehicle the adult world strives to perfect was already operational under the Christmas tree the night St. Nicholas was last abroad. And all had a singular advantage over their grown-up counterparts: They are not lethal.

Sales of radar rocket cannon, air pressure propelled rockets, space ships, guided missile bases and the like have grown to a $10 million business, up 100% in the last year, according to the Toy Manufacturers of the U.S.A., Inc. And there's no sign that the trend is about to reverse itself anytime in the near future . . .



One day these children who now play at space flight may well participate in the real thing, the beginning of the exploration of outer space.

Wilson's Missile Program Far From Settled

By Seabrook Hull

As m/r went to press, no decision had yet been reached on how to follow up Defense Secretary C. E. Wilson's November Memorandum on roles and missions. This was particularly true where missiles were concerned. Very much up in the air, for example, was the future—if any—of the Army Ballistic Missile Agency.

But some things were clear:

—— Air Force's first-choice solution was to take over ABMA lock, stock and barrel and transfer it bodily to the AF. Barring that, AF may want the heart of ABMA—the Wernher von Braun team—broken up, with its experts filtering off into industry, preferably to firms with AF ballistics missile contracts.

—— As for the Army, parts of it anyhow seemed ready for a fight: At stake was one of the world's most proved ballistic missile research and development groups and a 1650-mile Intermediate Range Ballistic Missile, *Jupiter*, which Army figured it had every tactical and strategic reason for using at will in combat.

—— The Navy, in its quiet, sophisticated way, had won the biggest victory of all. The sea-going service was no longer a junior partner in somebody else's IRBM program, but instead had Wilson's official go ahead to develop its own Fleet Ballistic Missile, *Polaris*. Moreover, once it was working, the Navy had assurance it would be able to use it operationally.

—— Interservice politics seemed to be playing a bigger role in the Army-Air Force squabble than basic considerations of national security. For that reason Congress—determined to find out what all the fuss is about—would probably have the biggest say in the final outcome.

The basic ruckus seems to date clearly from the 1947 Key West roles and missions directive that gave the newly-formed U.S. Air Force sole responsibility for the strategic delivery of nuclear weapons. It was then that AF and Navy slugged it out in the headlines, the latter determined to discredit the B-36 superbomber and the former bent on sinking the supercarriers.

After a lot of noise and foolish talk, this squabble was "compromised" by allowing both services to keep their "sitting ducks." It is interesting to note, however, that then, as now, it was the AF that hit first.

This is all history, and defining the generalities of the course and conclusion of events a decade back is a relatively simple matter.

However, sorting out a Pentagon fight that's only beginning and on which Wilson has clamped the tightest censorship is not so easy. Honest convictions abound. So do "facts". But rationalizing these "facts" and convictions into truth and good judgement is something else again. Top Army echelons, for example, seemed inclined to do just as the boss—Wilson—directs.

Sorting this one out to the interests of the country will take the trained politician's intuitive knowledge of, and long experience with people. That's a proper job for Congress.

Facts and Appearances

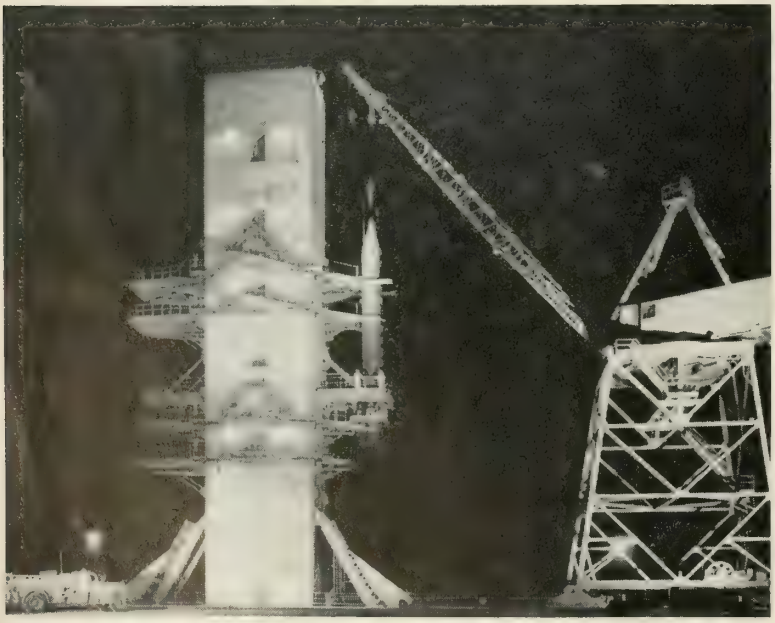
Meanwhile, the honest reporter's task is to report the few real facts that finally came to light and what various situations *appear to be*, after the best possible job of reporting. After checking top officials of Army, Navy, Air Force and Defense, these are the facts and appearances:

The first thing to make clear is that Wilson issued his now-famous November memorandum without having first decided even in general terms how the directive was to be carried out. Towards this end, repeated studies, meetings and investigations are now being undertaken. Additionally, plans had already been made to conduct an objective, "non-partisan" comparative analysis of the Army *Jupiter* and the AF *Thor*—the two IRBM principles of the current dispute.

The makings of this particular interservice fight date from the fall of 1955 when both the AF and Army were given official IRBM go-ahead. Army set up ABMA and put *Jupiter* development under Wernher von Braun. With the famous German V-2 developer were some 130 former German missile experts. In partnership with ABMA was Jet Propulsion Laboratories, of California Institute of Technology. AF contracted out *Thor* development to Douglas Aircraft Co., Bell Telephone Laboratories and the AC Sparkplug division of General Motors.

Both were announced as IRBM projects. Like the Intercontinental Ballistics Missile (ICBM), they posed unprecedented challenges to science and industry. Not the least of these was the requirement for very accurate guidance.

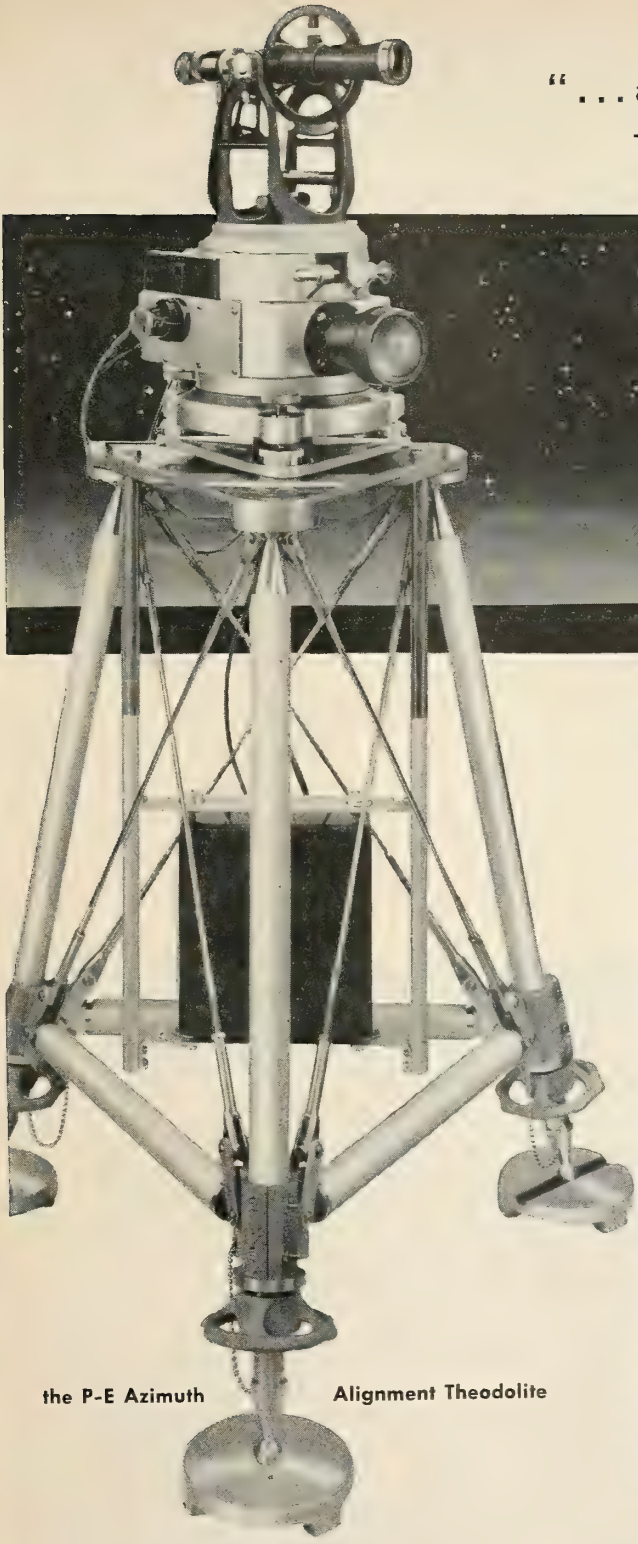
Considering information released



This test stand at ABMA's Redstone Arsenal, Huntsville, Ala., is capable of conducting two full-scale JUPITER test runs simultaneously. For an idea of the scale, note the man and truck at lower left. The missile in place is a REDSTONE.

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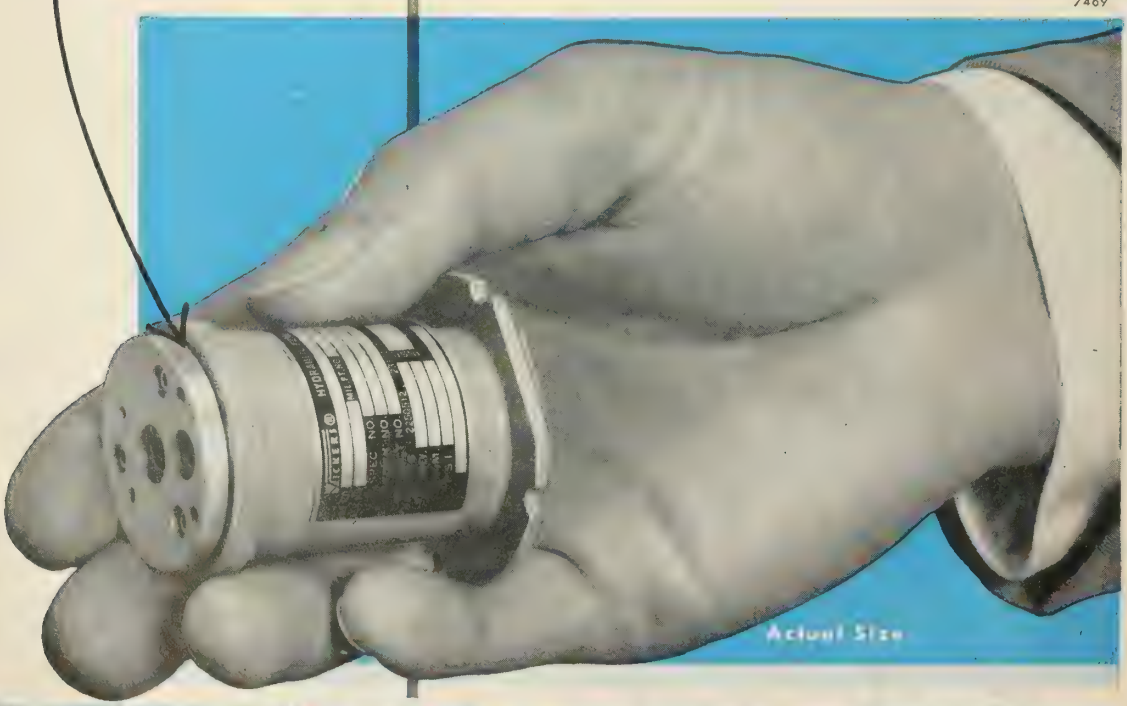
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so far on the destruction radius of nuclear warheads from ground zero, this would probably mean coming within a mile or two of a target 1500 miles away, or a guidance accuracy of well under 1%. Both must be able to carry thermo-nuclear warheads. And with it all, an over-riding sense of urgency, for there could be no doubt that Russian ballistic missiles got maximum effort.

Trouble brewed beneath the surface almost from the beginning. AF considered the IRBM a Tactical Air weapon and saw *Jupiter* in the hands of the Army as a threat to AF roles and missions. Army argued that with advances made in high-speed land mobility, the missile extension of artillery range to 1500 miles was not only logical but vital to a field commander in planning and covering day-to-day troop movements. Both services figured then, and still do, that much of their future importance in the missile age depended on developing and being able to use their own IRBM weapons.

Furthermore, except for the Navy with its special problems, AF insists that it have exclusive IRBM operational responsibility; that Army not be allowed to use anything over 200 miles. Navy, perhaps as part of its campaign to win the right to independent IRBM development, supports the AF stand.

Other facts undoubtedly contribute to the situation, such as the traditional jealousy between government and private industry in the field of development. *Jupiter* is primarily the product of a government team. *Thor* development, on the other hand, though paid for by AF, is the job primarily of private industry.

In the bitterness and rancor that's boiling up, you hear other comments too —that Wilson's General Motors background may have influenced his decision against the Army. Chrysler, who now manufactures the 300-mile *Redstone,* has long been thought to be the logical *Jupiter* contractor, whereas GM, through AC Sparkplug, has a very important *Thor* contract. A few scattered people will even tell you that the number of Germans on the *Jupiter* team prejudice the Army's position.

Meanwhile, both the Army and AF programs have made unexpected, rapid progress. Both the *Thor* and *Jupiter* missiles are scheduled to make their first test flights within the next few weeks. *Thor* appears to be at Patrick AFB already. *Jupiter's* reported to be en route. Once first prototypes have been fired, the normal procedure is to follow up with a number of test launchings. Then the real job of evaluating the two missiles really begins.

There are persistent reports around the rambling halls of the Pentagon that some top AF civilians as well as Defense Department missile czar E. V. Murphree have already conceded privately that *Jupiter* has the edge, particularly in the all-important field of inertial guidance.

Thus, not only was the AF threatened with having an unwelcome helpmate in what it considers its exclusive responsibility — TACAIR — but insult was to be added to injury by having that partner better equipped. Suggestions have been made at high levels that *Thor* should be dropped, but they do not appear to have gotten very far. There's every indication instead that, unless Congress steps in, the best of *Jupiter* will be lifted for the *Thor* and the former dropped. An Army suggestion is that, considering the importance of "getting there firstest with the mostest," development on both missiles should continue full tilt.

ICBM Duplication

An AF answer to this view is that the country cannot afford the expense in money and manpower of two duplicate IRBM projects. AF appears to feel that it waters down possible maximum effort on other high priority projects. The question may be raised: What about the AF's two ICBM projects?

Though the Navy reports excellent technical liaison with ABMA during the life of their joint venture, there's little doubt that Navy's glad to be out on its own—free of the liquid propelled *Jupiter* with all its unpleasant shipboard handling problems, and able to concentrate 100% on the solid rocket *Polaris.* Navy's also grateful, however, for having had ABMA help in getting *Polaris* off to a flying start.

The puzzling thing about Wilson's November memorandum remains that it was promulgated and released to the public without any clear idea of what to do next.

The assumption appears to have been in both the Air Force and Wilson's shop that this directive would be accepted as a matter of course; that neither private dispute nor public debate would ensue. This would seem to indicate not only a critical lack of awareness of the specific situation but of human psychology as well. For the Army reaction at the working level has not been placid acceptance. It's doubtful if tempers will be held in check during the hearings on Capitol Hill.

Most rancorous will be the restrictions reportedly imposed by Wilson on the imparting of full views and information. It is a characteristic of the Defense Secretary that he likes his department to present a composed, solid front to both the Congress and the general public. It's liable, however, to be quite a raucous show before it's over, one that may ultimately show sharp splits even within the Army itself.

Though nothing has been specifically decided, AF fully intends to get Wilson's approval and Congressional appropriations for taking over ABMA intact. If it can't do that, according to a top AF spokesman, "It will be better for the country if the ABMA team were broken up and the individuals filtered out into industry and other organizations." This view seems to ignore the fact that individual talent and ability is only one aspect of ABMA's success. The other, every bit as vital, is the ability of these men to work together.

Meanwhile, Army isn't giving up without a fight. The first battle will be to try to keep *Jupiter* development in the Army budget for at least another year. The Defense Department apparently has already decided against this. But the odds are that Congress will prevail upon Pentagon authorities to change their mind, or at least defer action until the fiscal 1959 budget is debated 12 months hence.

Army will also put up strong arguments for being given roles and missions responsibility for using IRBM's. This field, however, is one the legislators tend to shy away from, figuring that the determination of roles and missions is indeed the responsibility of the executive branch of government.

The case for retaining the ABMA-JPL team as an active ballistic missile development organization will be based on performance to date—namely a whole family of *operational* ballistic missiles with useful ranges from eight to 300 miles. They will cite *Jupiter-C* performance and the fact that Redstone Arsenal at Huntsville, Ala, has the know-how and the basic hardware for launching an earth satellite into an orbit.

An obvious question will be: Is it good business to just throw up the some $200 million that's already been spent on *Jupiter* development? In this connection Congress will be bound to ask just why the Defense Department first said "go ahead" and then a scant two years later said "stop".

On the face of it, no matter what the best decision on roles and missions might be for the country, the proof of ABMA-JPL performance is something that is neither easily discredited nor readily ignored. Leaving interservice politics, roles and missions differences and possible budget limitations out of it entirely, it may well be that Congress will see merit to the proposal m/r offers in this issue—that ABMA be established as an entirely separate agency, like NACA, free to continue its research unfettered by service rivalries. After all, the vital thing is to preserve our weapons superiority over Russia.



The first successful application of a moving pick-off head to a new, medium speed digital computer has been reported by engineers of Northrop Aircraft, Inc. With the device it is possible to record or read on 64 magnetic memory drum channels using only two pick-off heads. While the drum revolves at 1,800 rpm, the moving heads make one full up-down cycle every two seconds. Previously, 64 separated heads, one for each channel, were required, resulting in greater weight and complexity. Pick-off hid circuitry requirements, for example, have been reduced by over 95% by Northrop's new development.

$8 Million Computer to Aid Missile Test

Rapid reduction of flight test data using a powerful new computation facility is expected to permit one test missile to do the work of many during development programs.

A General Electric Co. Missile and Ordnance Systems Department engineer, A. W. Robinson, disclosed plans for the new facility in a talk before the International Congress on Rockets and Guided Missiles held in Paris, France last month.

Known as a "real time" closed-loop analysis system, two high speed "Univac" computers comprise part of the system. The computers will be installed by the USAF at Holloman AF Base in 1958. Cost will be $8 million.

The new technique is intended to allow rapid data reduction during missile flight. Reduction will take place in a few seconds and enable new instructions to be sent to the missile to obtain a wider scope of information.

Official announcement that an International Business Machines Corp. computer will calculate and predict the orbit of the *Vanguard* satellite has been made by the Navy Department.

The IBM 704 computer and 740 Cathode Ray Tube Output Recorder to be used will be located in Washington, D. C. It will first receive and process data from the *Vanguard* vehicle as the rocket reaches third-stage burnout and then will be switched to make calculations on the satellite's orbit based on data from Minitrack radio tracking stations located in the Western Hemisphere.

Dr. Paul Herget, Director of the Cincinnati Observatory will head the staff of the Washington facility to be known as the *Vanguard* Computer Center.

Construction of a building to house the Center is reportedly underway in Washington. A computer at another location will be available as a back-up facility for emergency use.

Defense Secretary Wilson's word as to who shall build and fire what missiles may not be so final as he would wish. An m/r check of Congressional sentiment on the November Memorandum on roles and missions reveals that all is not peace and acquiescence on Capitol Hill.

If the reaction at the recent American Rocket Society annual meeting (m/r, Dec., p. 24) was one of shock and consternation, that of the nation's legislators is one of astonishment and confusion, highlighted by a firm determination to "get to the bottom of things" early in session.

At stake is not only the Army's claim to a long-range artillery weapon—the Intermediate Range Ballistics Missile—but the future of what is reputed to be the hottest ballistics development team in the nation—perhaps in the world, the Army's 12,000-man Redstone Arsenal at Huntsville, Ala., including 130 former German rocket experts under Wernher von Braun.

Concentrating mainly on the members of the Senate and House Armed Services Committees—who have the biggest say in deciding who gets how much money for what—m/r found Democrats cautiously vocal; Republicans, strangely silent. One view was virtually unanimous:

"We want to know a lot more than we do now about the details leading up to this decision, and what it portends for the future."

Senator John J. Sparkman (D., Ala.), for example, has this to say:

"I think the Army is entitled to continue development of the *Jupiter*—undoubtedly, they are further along than anybody else. To stop this program now is to penalize our missile programs and already accomplished industry efficiency. It would be extremely wasteful.

"Secondly, the Army has developed the strongest possible team, and one that has shown results in course of the one year it has been operating.

"I think as a matter of military tactics the Army is entitled to the use of missiles such as the *Jupiter*, or others, wherever they can accomplish the mission for which the Army is intended.

"All services should be allowed to do all they can toward development of missiles. Let the Air Force develop their *Thor*, let the Army develop the *Jupiter*, let the Navy develop the *Polaris*. If another war should come we'll need all of them...

"It is unthinkable that the United States Government would

Capitol Hill Wants Facts on Wilson Memorandum

do such a foolhardy and wasteful thing as to throw away many millions of dollars that have already been invested in the work done by the Army. It would be little short of *criminal* to waste the tremendous brainpower and scientific knowhow the Army has been able to bring together for this program.

House Armed Services Chairman Carl Vinson would not commit himself either way, but the emphasis he gave to his no comment was significent in itself. He said:

"I shall have nothing to say until Congress reconvenes. First I want an opportunity to study the Wilson directive.

"As chairman, I don't think it behooves me to comment on the directive put out by Secretary Wilson. It is his responsibility to assign roles and missions to the armed services. This responsibility naturally includes the problems of rockets and guided missiles.

"Until the Defense Department comes before my committee to explain itself fully as to its intent, I, for one, shall withhold any comment."

And from Rep. Arthur Winstead (D., Miss.), this statement:

"I want to talk to those folks before I make up my mind. I want to talk to everybody. We have to have some executive sessions and some open sessions of our committee. I want to see us explore the whole kit and kiboodle.

"Those folks across the river will just have to come up here and explain to us what they have in mind."

Rep. Paul Kilday (D., Texas):

"I have a fear and a disappointment in this regard of the assignment of roles and missions. But it occurs to me in my fear and disappointment that we might see a new B-36 fight arising out of this new directive.

"I intend to do my best now that Congress has convened again and demand a complete review of the wasteful policy stipulated in the Wilson directive."

That there seems to be a good chance of another knock-down, drag-out fight brewing seems apparent. You hear the same kind of rumbling you did just after World War II when as a result of the 1947 Key West Roles and Missions directive, Air Force and Navy, using headlines as their big calibre ammunition tried respectively to sink the super-carrier and shoot down the B-36 "super-bomber." One member of the House Armed Services Committee put it this way:

"The Army will fight like hell to keep Dr. von Braun and its Redstone Arsenal."

The AF, it appears, is just as determined to see Redstone either eliminated or absorbed into the AF structure.

"Of course I need more time to study this question, lest I be accused of hasty ill-founded opinion. I'm a great believer in the need for strong airpower. I'm lacking in knowledge. I'm not sure the Army should be so limited. We have already limited them in the weight of their aircraft. Now limiting them in the range of their missiles and rockets makes me pause and wonder about the plans behind the Secretary's directive.

"I would like him to explain more clearly how he plans to limit distance. Personally, I feel a logical distance for these new weapons would be 500 miles.

"There are other factors I want to talk about. First of all I feel that we in the legislative branch have to allow these directives to be made by the executive branch. In this case something had to be done. It was.

"I'm in favor of doing. But that doesn't mean I'm in accord with the directive. What I'm saying is simply this: It is the role of the executive office to handle the broad overall policy as it affects the strength of our country.

"We are engaged in creating new instrumentalities for the defense of the nation. I can understand, of course, the Army must be bitterly disappointed. Undoubtedly they fear that in the complex assignments for the defense of the nation, they will have a minor role.

"I'm not prepared to discuss that aspect at this time. After all there must be the opportunity for discussion. But there is one thing I shall have my say on. Congress must stay out of the conflict, if any, on strategy and tactics. That is the role of the military men.

"In a relatively short time we shall find out the full significance of the directive. If it develops that one of our services is prejudiced, we shall, in our own way, discharge our proper duty to the people."

Rep. Victor Wickersham (D., Okla.):

"If this directive has the approval of the Joint Chiefs, that is one thing. If there is disagreement, that is something else. If there is over-lapping in the field of guided missiles, it won't hurt. Competition is good. The Russians are in this thing for keeps. So duplication will do no one any harm.

"I think Wilson is trying to do a job of coordination. But in practice, those things don't always work out as they did on paper. I can only hope that Wilson is not trying to hold down technological development.

"Another thing I'm wondering about is where the Budget Bureau fits into the directive. They have the last word over there because all they have to do is withhold funds, even funds which have been appropriated by Congress."



Maj. Gen. John B. Maderis, ABMA Commanding General, The Senator from Alabama, The Right Honorable John J. Sparkman (D.) and Maj. Gen. H. N. Toftoy, Commanding General, Redstone, Arsenal, during a visit of the Alabama Congressional delegation to the Huntsville facility last month.

Twenty-five Nations Meet in Paris For Congress on Missiles

From our correspondent

PARIS—Twenty-five nations were represented at the International Congress on Rockets and Missiles which took place in Paris last month. The meeting was organized by the Association pour l'Encouragement a la Recherche Aeronautique and its success was largely due to the work of the association's president, Jean Venturini. The 125 delegates attending the Paris meeting heard talks in several different languages on all aspects of missile and rocket activities.

G. Bory, a former French naval engineer, discussed rocket-powered missiles with special reference to development efforts between 1917 and 1947. Dr. M. Lebrun, French scientist, talked about meteorites and "flying saucers." A paper on international astronautics was read by Germany's F. L. Neher, historian of the Gesellschaft fur Weltraumforschung. He also discussed Germany's 30-year period of work on rocket development.

A. W. Robinson, of International General Electric, talked on guided missile development work in the U.S. A. Ducrocq, head of Societe Francaise d'Electronique et de Cybernetique, discussed atom-powered rockets. This subject was also discussed by Dr. F. Winterberg, a German specialist, and by two French engineers, Th. Reis and M. Gauzit.

General Electric's contribution to Vanguard was the subject of a paper by R. E. Small. Dr. G. S. James told the meeting about the Rocket Research Institute, which he heads, and also discussed the International Geophysical Year. J. Persch of U.S. Navy Ordnance, talked on the calculation of turbulent boundary-layer heat transfer in supersonic and hypersonic nozzles. Three Belgian scientists—P. Glansdorff, P. Jaumotte and S. Passelecq—discussed rocket performance. The "Litergolici" system of propulsion was described by Professor Corellli of Rome University. J. A. Vandenkerckhove of Brussels University spoke on erosive combustion of a double-base propellant. Dr. C. Belmondo, of Turin, Italy, discussed solid propellants. Propulsion problems were the subject of a paper by Captain G. Partel of Rome. Professor H. J. Zucrow and A. R. Graham of Purdue University discussed the cooling of rocket motors.

H. Bednarczyk of the Vienna Institute of Technology spoke on water vaporisation's contribution to the theory of the rocket. Professor M. J. Zucrow and J. R. Osborn of Purdue University discussed determination of the dynamic response of pressure transducers by means of the high-pressure shock tube.

In the field of ballistics and flight mechanics speakers included: J. Hely, deputy chief of France's Ecole Nationale Superieure du Genie Maritime; E. Sanger, head of Germany's Forschungsinstitut fur Physik der Strahlenantrieb; J. J. Gait of the Royal Aircraft Establishment, Farnborough; Dr. G. Fellner, of Achen, Germany; P. S. J. Vernotte of Paris; L. C. Frager of Paris; Max Plan of France's Laboratoire d'Aerothermodynamique; Dr. F. H. Devienne of France's Laboratoire Mediterraneen de Recherches Thermodynamiques; E. Finkel of France's Societe Matra; I. Rind and Jean Casteil of the French IBM company; I. Dreyfus of France's Compagnies des Machines Bull; F. H. Reynst of the Netherlands; Prof. A. Bartocci of Italy's Terni company; Dr. W. Trommsdorf of Deutsche Versuchsanstalt fur Luftfahrt; Dr. James Heyda, Allison Division, General Motors; and H. R. Voellmy of Zurich, Switzerland.

Guidance problems were discussed by the following: Colonel P. Gaudillere of France's SFT company; F. Muller of Gottingen, Germany; P. Devergne of France's Societe de Fabrication d'Instruments de Measures; Dr. W. C. Hodgson and J. N. Ryon of the Naval Research Laboratory, Washington; I. Guanella of Baden, Switzerland; and E. Perret of Zurich, Switzerland.

Ground installations and special techniques were the subject of papers by: Dr. A. Gerber of Zurich, Switzerland; General W. W. Hohener of the U.S. Navy's Bureau of Ordnance; B. Winandy, of Paris; H. Gelly of France; R. Syre of France's Pechiney company; A. Ferchaud of Paris; Dr. B. Langnecker, of Vienna; Dr. G. Golubovic of Paris; Major F. Violette of the French Air Force; and J. Duflos, head of France's Textiglass company.

Papers on the legal and economic aspects of astronautics were read by: E. Winandy; Andrew Haley of the American Rocket Society; and M. O. Maquenne of the French Societe d'Economie Politique.



A MATRA air-to-air missile has been installed underneath the prototype of the Dassault Mirage, France's Mach 1.5 fighter prototype.

Aero Digest Readers May Choose m/r

Subscribers to *Aero Digest*, which suspended publication with the December issue, will be given their choice of receiving MISSILES AND ROCKETS or AMERICAN AVIATION Magazine.

American Aviation Publications announced that it has agreed to fulfill all unexpired subscriptions to *Aero Digest*. In the event that the *Aero Digest* reader already receives the American Aviation publication of his choice, he will be given equivalent credit for extension of his subscription.

Founded in 1937 by President and publisher Wayne W. Parrish, AAP is the world's largest aviation publishing organization. In addition to the 20-year-old AMERICAN AVIATION Magazine, with a circulation of 46,000, and MISSILES AND ROCKETS, which already has attained a paid circulation of 8,500 in less than six months, the company publishes *American Aviation Daily*, *American Aviation World-Wide Directory*, the *Official Airline Guide*, the daily *Air Traffic News*, *Airports* weekly newsletter, and *Who's Who in World Aviation*. In addition, the Air Information Division provides a specialized service that digests time tables, fares and charges for scheduled airlines. Company headquarters are at 1001 Vermont Avenue, N.W., Washington, D.C.

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Special attention has been given to the metallurgy of the component parts to insure unfailing service in atmospheres of dangerous propellants such as fuming red nitric acid and unsymmetrical dimethyl-hydrazine.

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The Scott 8100-A2 Air Pak incorporates the latest advances in chemical resisting materials. Two small compressed air cylinders are used instead of one large cylinder. This reduces bulk and makes the unit easier to wear with protective clothing.

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Titan Configuration Revealed by Glenn L. Martin?

A Martin Company ICBM ad, in the January issue of the American Rocket Society's *Jet Propulsion* shows a more or less conventionally appearing two-stage, triple-finned rocket. A check with the Pentagon indicates that the configuration is a "bit too close" to the actual *Titan* Inter-Continental Ballistics Missile now being developed by Martin for the AF. A close replica of the missile in the ad appears below.

A Martin Co. spokesman when asked to comment on their ICBM ad and its similarity to *Titan* said only: "I can neither confirm nor deny . . ." The British magazine *Flight,* however, in its December 7 issue reports that *Titan* is a two-stage weapon with the sustainer rocket mounted directly over the booster. General indications are that the length of the missile mounted and ready to fire approximate 100 feet with the diameter of the booster maybe 10-to-12 feet; that of the warhead and final stage, 6-to-8 feet. Fueled weight is undoubtedly well over 100,000 pounds.

These reports plus the fact that AF may shelve the *Navaho* project in order to be able to concentrate even more on ICBM development indicate that the state of the art is a lot more advanced than most people thought it would be two or three years ago. The advanced state of the ICBM's could be the main reason Defense Secretary Wilson is so willing to limit research and development money.

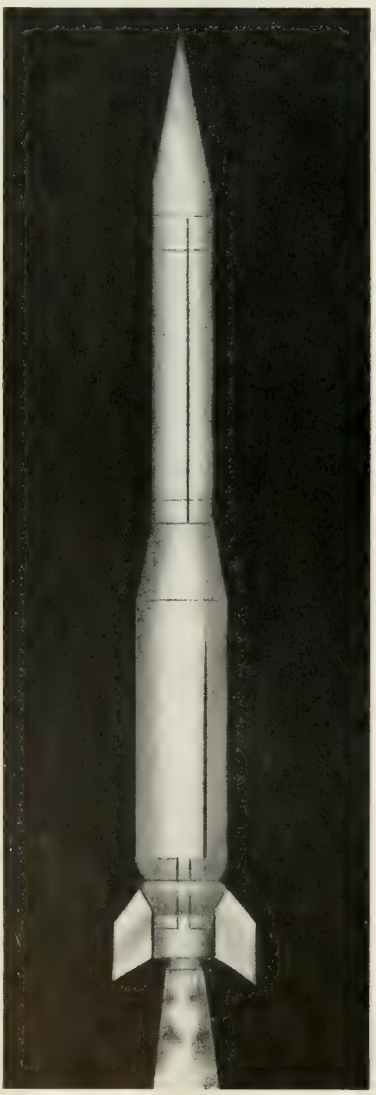
Puzzling on the accompanying artist's conception is the clear indentation in the missile body near the tail section, unless it is that the aerodynamic guidance fins are dropped off before the booster has burnt out.

Also, the warhead is similar to pictures of Martin test cones for the Vanguard satellite launching project. More probably, Titan's nose cone will be a compromise between the blunt, high-drag-to-weight ratio configuration and the sharply tapered high-speed reentry design, i.e., both tapered and blunted.

Flight reports that Aerojet-General Corp. is responsible for *Titan's* stage one motor, with Reaction Motors, Inc., responsible for chambers. Nothing specific has been released as regards the thrust of the first stage booster, but it is reported to be on the order of 250,000 pounds, or at least that's some kind of design target.

Another indication of the advanced state of the ICBM programs is a recent report that considerable Convair *Atlas* staff are moving to Patrick AFB "permanently." Meanwhile, Martin's rocket engine and systems test facility at Denver, Col., has reached an advanced stage of completion.

It begins to look increasingly as though AF placed its bets well when it contracted for ICBM development.



TITAN?

news briefs

NORTH AMERICAN AVIATION now has three IBM 704 electronic data processing machines in operation to help speed research and development of supersonic aircraft, missiles and rocket engines. Two are at its main Los Angeles plant, the third at NAA's Rocketdyne Div. at Canoga Park, Calif.

BENDIX AVIATION CORP. has acquired assets of Sheffield Corp., Dayton, Ohio producer of precision gauging and measuring instruments. Current Sheffield sales run about $24 million annually.

TEXAS INSTRUMENTS, INC., transistor producer, expects final 1956 earnings will reach $2,100,000, up almost 30% from $1,582,000 in 1955. Sales are estimated at $44 million against $28,685,000 last year.

ELECTRONIC CONTROL SYSTEMS, INC., Stromberg-Carlson affiliate, has leased a fourth building in West Los Angeles area at 2205 Stoner Ave.

ACF INDUSTRIES, INC. earned $3,758,000 on sales of $129,589,000 for its first six months ended October 31 compared to $3,875,000 on sales of $117,274,000 for like period last year.

AUTONETICS DIVISION, North American Aviation, Inc. has purchased a 15½ acre plot of land adjoining present division headquarters to be used for future expansion.

DOUGLAS AIRCRAFT CO. and United Auto Workers have agreed on an initial contract covering workers at its Charlotte, N. C. *Nike* missile plant. It expires early in 1958.

AGREEMENT SIGNED between Hughes Aircraft Co. and Aircraft Industries Workers at company's Culver City plant calls for wage increase of 7¢ to 15¢ an hour. It also provides hike next year of 6¢ to 11¢ and institutes a cost of living clause. Hughes recently signed a similar contract with International Assn. of Machinists at its Tucson plant.

SMALL BUSINESS WON at least a half-share of the $624,700,692 in purchase orders issued by North American Aviation during its fiscal year 1956. Some 11,028 firms having less than 500 employes each received contracts worth $312,399,366, up from $275,725,886 in 1955.

CONVAIR ASTRONAUTICS new $40 million plant being built near San Diego for *Atlas* intercontinental ballistic missile production is reported on schedule. Engineering laboratory is the first building slated for completion.

LITTON INDUSTRIES registered sales of $6,230,000 for quarter ended October 31, exactly double the $3,115,000 for same period in 1955. Profits were $401,000 compared to $212,000 a year ago. Litton backlog reached $36 million and assets exceeded $13 million.

INTERNATIONAL NICKLE CO. OF CANADA, LTD. has announced a joint government-company financed $175 million expansion which will increase its annual output approximately 50% by 1960. Firm recently raised nickle prices 9.5¢ per pound to 74¢, first hike since November 1954.



Rocket Trends

By Erik Bergaust

Army still hasn't said anything about their record-breaking rocket flight four months ago. A favorite topic of conversation at the American Rocket Society annual meeting in New York a few weeks ago, it appears Drew Pearson predicted last July the Army was about to shoot a missile some 3,000 miles. The firing took place September 20. *Life* magazine was first to tell the story (October), newspapers picked it up and people started to talk about the venture. The outstanding Army missile firing was discussed in barber shops at Cocoa Beach near Patrick and at Huntsville and wherever rocketeers get together.

The public might have been led to believe that this Army missile was the *Jupiter* prototype. However, industry people refer to the record-breaking missile as a *Jupiter* "C," not a *Jupiter* IRBM. In its November write-up m/r indicated the *Jupiter* "C" consists of a modified *Redstone* as a booster, a cluster of scaled-down *Sergeants* for the second stage and another scaled-down *Sergeant* cluster for the third stage. The *Jupiter* "C" launched on September 20 supposedly went as high as 650 miles, according to some—others say 680 miles. Maximum velocity of 15,000 mph and range of 3,300 miles have been mentioned. It remains a strange phenomenon—if these figures are true—that the Army will not claim officially the world's speed and altitude records for rockets.

Meanwhile, the Air Force is closing in on the Army ballistic missile lead. Big payoff for Air Force missile planners stems from their wisdom in running two parallel ICBM programs—*Atlas* and *Titan*—and using the skillful planning experience of ARDC. Result: Air Force *Titan* and *Atlas* are far more advanced than was contemplated a year ago. We predict the recent Army ballistic rocket publicity will look like peanuts compared to what Air Force will get, for only the Air Force can send a rocket to the moon . . . This will happen sooner than you think . . .

Beyond that Air Force is understood to be thinking in terms of nuclear-powered rockets. And the airmen soon will learn that this earth of ours is much too small as a proving ground for such high-punch stuff. So the United States Air Force might have to become the United States Space Force—whether anyone else likes it or not.

So you'll hear more and more about the Air Force planning to send a rocket to the moon. And you'll be hearing more about the fact that we're racing the Russians in this respect too. Some ace WDD planners and top notch scientists will see to it that we get there first, we predict. Furthermore, we have a feeling one particular name, eventually, will stand out in this connection—that of Krafft A. Ehricke. When we asked a high-ranking AF officer recently whether the AF was interested in space flight, he said: "Not only are we interested, but note that when man goes into space, it will be an air force venture, and the guy in the driver's seat will be an Air Force pilot!" There's no question the AF is a logical choice for pursuit of the space flight goal. Nevertheless, we feel certain the Navy wants to get into the act too . . .

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Washington Spotlight

By Henry T. Simmons

The Navy has assembled a team of four top contractors to carry out the development of the Fleet Ballistic Missile, this column has learned. Responsible for the airframe is the Missile Systems Div. of Lockheed Aircraft Corp. Aerojet-General Corp. has been assigned the propulsion unit, while General Electric Co. and Massachusetts Institute of Technology will work on the guidance and fire control features.

•

Selection of the contractors means that the Navy will be relatively little affected by the transfer of control over the development of the *Jupiter* IRBM from the Army to the Air Force. Although the *Jupiter* was originally set up as a joint Army-Navy project, the sailors some time back worked out a revised program which called for a solid rather than a liquid-propellant weapon and accordingly proceeded with its development. Thanks to this preliminary effort, it will only be necessary to increase the scope of some of the earlier work to assure the Navy of a full-fledged FBM development program of its own.

•

Fate of the Army Ballistic Missiles Agency and its cadre of *Jupiter* scientists and contractors may well prove to be one of the knottiest administrative problems in the entire missile picture during the next few months. In theory, the Air Force is free to finance continued development of the weapon after next July 1, but Pentagon insiders are dubious about the prospects of this in view of the pinch on funds available to the Air Force for research and development. They believe the airmen will abandon almost all of the *Jupiter* work, with the result that an experienced scientific and industrial team will be lost. But so far, no one in the administration has come forward with any solution to the problem (see m/r editorial page 7).

•

The simplicity and low cost of the infra-red guidance system of the Navy's *Sidewinder* air-to-air missile has so impressed the Air Force that it has ordered an IR version of the Hughes *Falcon*. Unlike their radar-guided counterparts, the heat-seeking *Falcons* will require no external fire control. Since most of the aircraft which might use them will come equipped with a half a ton of radar fire control apparatus, it appears likely that the new birds will be mixed in with radar *Falcons* to offset countermeasures.

•

Navy budget request for Fiscal 1958 includes funds to assure a "modest growth" of the Point Mugu missile flight test range off the coast of California. It will provide for vessels to serve as down-range tracking stations as an interim measure, although ultimately the range might extend to the Galapagos Islands and beyond.

•

So-called "zip" fuels may provide a spectacular performance boost for the Navy's air-breathing missiles when they become available. Although the high-energy fuels are presently slated for ramjet-powered birds, it is likely they will also be feasible for turbojet-powered weapons. Their big advantage: a 40% boost in fuel energy for a given volume, with consequent range and speed increases. The Navy has started work on a $33 million zip fuel production plant at Muskogee, Okla.

book reviews

Reference Data for Radio Engineers. *By International Telephone and Telegraph Corp., 4th edition. Published by IT&T, Publication Dept., 67 Broad St., New York 4, N. Y. 1121 pp. $6.00.*

An improved and expanded edition of a reference data handbook which has been popular since 1943. The book was designed to save time spent by radio engineers in finding data to solve a wide variety of problems needing equation, curve, table and monograph information.

The new version contains new and completely revised information to meet current requirements in the radio engineering field. These include such subjects as semiconductors and transistors, helical antennas, nuclear physics, scattering matrixes in waveguides, etc. A tremendous quantity of data is packed in this one volume. H.P.S.

Jane's All the World's Aircraft 1956-57. *Compiled and edited by Leonard Bridgman. Published by McGraw-Hill. $25.*

For the first time in this renowned aviation annual there is a missile section. Mention is made of the Russian T-7A medium-range artillery rocket, a SAM developed from the German Rheintochter, "an improved V-2 type" ballistic missile, a winged jet-powered medium-range, bombardment missile, and the T-4A supersonic glide-bomb.

The missile section describes Vanguard and shows it diagramically. USAF, US Navy and Army designation systems are explained and all Western missiles are tabulated on four pages faced by the same number of familiar photographs. Although 42 U.S., 13 French, 10 British and one Swiss operational and research missiles are listed. The table includes the following items which the British Ministry of Supply states are not official:

(1) Armstrong-Whitworth Sea Slug, Royal Navy SAM, has four concentric booster rockets, measures 20 ft. long, resembles model shown in company's supersonic tunnel and has English Electric guidance system.

(2) A de Havilland infra-red AAM is to be standard for the Royal Air Force. It resembles a test vehicle revealed at the 1954 SBAC Farnborough show.

(3) English Electric SAM is a beam-rider with either Napier liquid rocket or Napier ramjet and Marconi guidance.

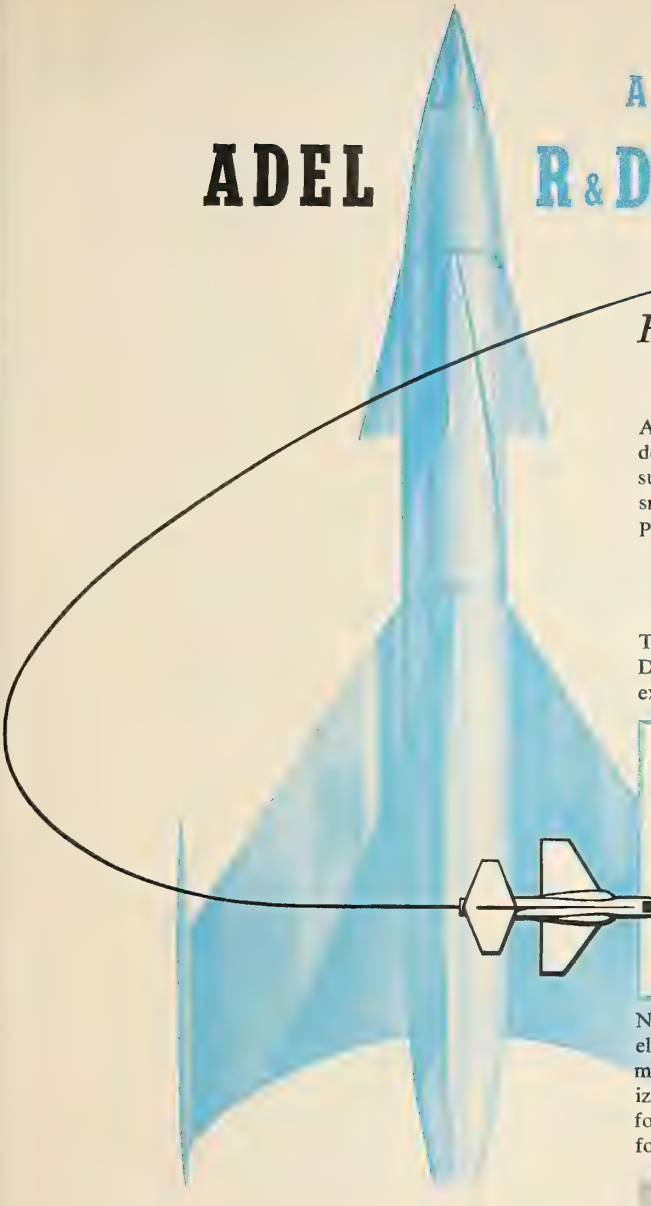
(4) Fairey has an enlarged development of the Fireflash AAM, 10 ft. long (without booster) which was the missile shown anonymously at the 1955 Farnborough show.

The 1956-57 edition of Jane's carries 13 more pages than did the 1955 volume on U.S. aircraft (121 in all)—more than one-third of the total and double the second entry, the United Kingdom. The Soviet Union is up from nine to fourteen pages although there is nothing not previously published elsewhere.

This is the 47th issue of Jane's and it follows close upon the award of a Paul Tissandier diploma by the FAI to Leonard Bridgman for his work as compiler and editor for 36 years. These diplomas have but rarely been accorded to aviation writers: Wayne W. Parrish, president and publisher of m/r received one last year, and only one other British writer—the late C. G. Grey—has ever been given one.

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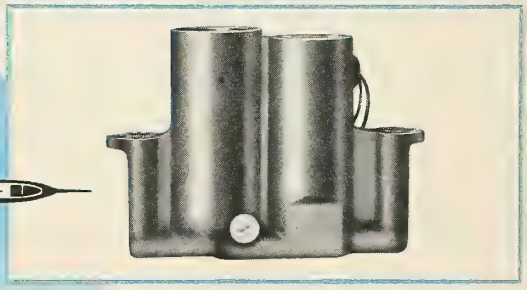


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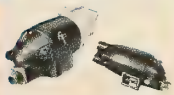


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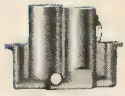
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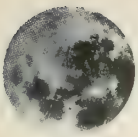
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Missile Miscellany

This page, to be a regular m/r feature, considers itself a kind of swap-shop for ideas. Like the mind, it abides no limits to its scope. Its objects are manifold. It's a meeting and mixing place for ideas, off-chance remarks and queries that might otherwise pass unexamined. But mainly, it aims to keep people thinking.

★ ★ ★

Shot through with bitterness, this remark from a man on the Jupiter team at Redstone: "We're all getting two-to-three-job offers a day from industry...good pay, too." From a Bomarc engineer: "Bust up the von Braun team, and U.S. ballistics missiles lose five years."

Then, at dinner the other night, this page heard a liquid propellant salesman toss out: "What the missile business needs is its own basic R&D agency, free from profit motives, politics, interservice squabbles and annual budget fights. Maybe Congress ought to take ABMA from Defense and give it protected status like NACA."

★ ★ ★

Space is neither "free" nor "empty." Plus all the bits and pieces of matter flying about, it's a massive energy spectrometer, including not only light and heat but also strong magnetic, electrical and gravitic (and who knows yet what other) energy gradients.

In the mellower hours of the annual ARS meeting, an aerodynamicist asked: "Why don't we ride these gradients? Carry just enough fuel to gather and convert space energy for propulsion—like a heat pump uses comparatively little power to concentrate a lot of vagrant outdoor heat inside where it'll do some good."

And a quip: "Make Newton's apple fall up, as well as down." But out of the past, this comment by Nobel prize winner Robert A. Millikan (founder of Cal. Tech.) to a student in 1922 is more provoking: "Man will discover the secret of gravity in work with very high voltages and heavy masses..."

★ ★ ★

Some recent unofficial Navy reasoning this page jotted down goes thus: "Return TACAIR to Army; perfect the pilotless interceptor; make MATS an independent all-service operation; and after ICBM kills off SAC, you certainly won't need a whole T. O. of men in uniform to carry out White House orders for an intercontinental count-down."

★ ★ ★

This page feels there must be some mistake but: Navy missed a publicity bet when it didn't claim World War II's sonar-directed torpedo as the country's first guided missile. And it heard an AF planner and programmer say Army is "very happy" with the now-famous November Memorandum wherein AF trades Army even-Steven, Talos for Jupiter.

★ ★ ★

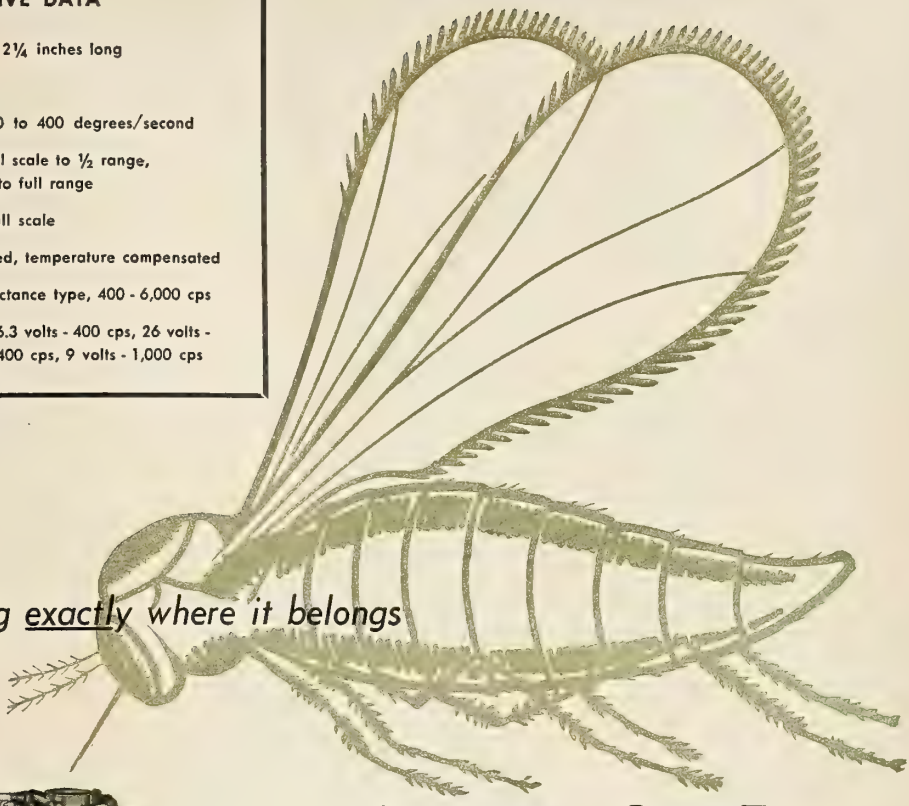
An NACA structures engineer, weary of cantilevering all manner of stores, engines, wings, etc., on both manned and unmanned fuselages, wants to know what's the matter with the aerodynamics of a disc . . .

. . . Picked up in passing: An H-bomb dropped on Los Angeles airport would knock out one quarter of this country's missile capacity . . . This page hears increasing demands for a degree in missile engineering . . . From a top Pentagon civilian when assured Wilson would soon quit: "I wonder if Bob Lovett would be willing to come back?" . . . And to the right, a Chinese "fire arrow" as it was launched around the year 1,000 A.D., which is about the time all this began . . .



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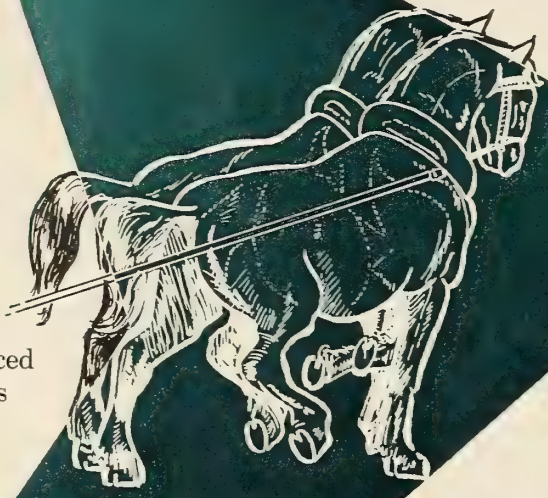
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VOL. 2 NO. 1
JANUARY, 1957

missiles and rockets
MAGAZINE OF WORLD ASTRONAUTICS

Navy Missiles Roles and Missions

By Rear Adm. James S. Russell, USN

Chief, Bureau of Aeronautics

THE IMPACT of guided missiles and rocket power is bringing basic and far-reaching changes to naval aviation. Changes in tactical concepts, changes in equipment, and changes in the efficiency with which the mission is performed are operational facts today. More is on the way.

Although these implications of guided missile and rockets to the air systems of the fleet are already immense, they are not yet seen as the total end in themselves. Although their influence upon concepts of sea-based airpower is almost immeasurable, they will in the foreseeable future fit into basic patterns of Navy air requirements.

These exciting new families of unmanned weapons will extend the striking and defensive arms of naval aviation in the same way that aviation itself extends the arm of total seapower, including surface and undersea forces.

We should perhaps note the past before discussing future influences of missiles and rockets on naval aviation.

The Navy has consistently advanced the art of missilry and rocketry from the start. Rocket power was first applied to naval aircraft as the well-known Jet-Assisted-Take-Off (JATO). Historically compelled by the restricted space available on ships at sea, the Navy has pioneered the development and use of assisted take-off devices, such as the catapult and JATO.

Today JATO is used more than ever, and its use in the future is assured, to extend our launching capabilities and literally to get us out of tight spots. A seaplane flying across the United States in 1944 was forced down in a pond. It was flown out with JATO.



The Navy's initial capability to deliver the atomic bomb—before we had our modern planes and when the bomb was an awkward gadget—depended on a jet-assisted-take-off. Currently, all our seaplanes and heavy attack planes have provisions for JATO use.

During and after World War II, development brought turbo-jet and rocket engines and with them aircraft of greatly increased speeds and altitudes. Flight potentials went beyond the testing capacity of existing wind tunnels. To obtain design information and data in this era of high speed and high altitude flight, research vehicles, both manned and unmanned, were powered by rockets. These projects were joint service efforts among the Air Force, the National Advisory Committee for Aeronautics, and the Navy. A series of rocket propelled airplanes and smaller free flight research vehicles were flown in a program participated in by many interested agencies. For instance, the Bell X-1 flown by the Air Force was powered by a Navy-Reaction Motors, Inc., developed engine which delivered 6000 pounds of rocket thrust.

The Navy's Douglas SKYROCKET, the D558-2, another rocket-powered research aircraft, was clocked at 1065 knots at 79,000 feet, back in 1951.

Highly instrumented rockets, with or without a pilot, flying from such different places as Muroc, California, and Wallops Island, Virginia, have augmented and confirmed a usable pattern of much needed data.

Today's high performance airplanes owe much of their success to the knowledge gained from the flight of rocket-powered research vehicles.

Many Firsts For Navy

There are many "firsts" in missile development on record which are the direct result of the efforts of the Bureau of Aeronautics. Among these are the first surface-to-air missiles known to have destroyed a target aircraft, the *Lark;* the first all-weather air-to-air missile system to become operational, the *Sparrow I;* the first ship-launched surface-to-surface missile to become operational, the *Regulus I;* and one of the first guided missile test and evaluation centers, the Naval Air Missile Test Center at Point Mugu, California.

In all of this past effort, the aim has been to take the conjecture out of design, to experiment and document, to refine and improve, and to put missiles and rockets to work on a practical basis.

To realize the advances, one only has to look at some of the early contractual documents. So little was known about the art as little as fifteen years

ago that development contracts were written loosely, and in vague, nebulous terms. Combustion chamber geometry was more "plastic art" than engineering. Performance calculations were educated guesses. In both guided missiles and rocket power applications the flight article was largely a product of fortunate estimates and the particular skills of artisan machinists.

Today's development contract is a good indicator of the progress achieved; specifications are called out with engineering precision and with a scientific know-how which reflects the testing and documentation experience typical of an established science.

In discussing the role of unmanned vehicles in future fleet aviation, we must also assess the present.

Within the organization of the Navy Department, the work and responsibilities for Navy missilry is shared between the Bureau of Aeronautics and the Bureau of Ordnance. Each of us has defense missiles—those used to destroy attacking aircraft, and attack missiles—those guided to enemy ships, submarines, and shore bases.

Modern rockets as weapons were founded, nurtured and firmly established in our arsenal by the Naval Ordnance Test Station (NOTS) at Inyokern, or China Lake, California. The present staff of over a hundred scientific personnel, plus many engineers and technicians grew from a cadre originally started by the Navy's Bureau of Ordnance at the California Institute of Technology. At China Lake the rocket is supreme. There it is the objective and also the means to the objective.

The Naval Ordnance Test Station has, as a result, an outstanding know-how in rocketry. In their work they recognize that the weak point in the ballistic rocket system was accuracy. The result of their staff work has been a milestone in air defense progress—a five inch rocket with a small guidance section added. Having been born in the desert and quite deadly, it was named the *Sidewinder*. Possibly because of its novel conception in the field of missilry, *Sidewinder* has two characteristics which stand out in this day of complex technology and complicated logistics. It is **simple** and it is **cheap.** There are an unbelievably small number of parts and a power supply weighing less than an ounce. It is the only missile whose cost compares to the price of a load of aircraft cannon bullets.

To round out the Navy air-to-air missiles, the Bureau of Aeronautics has developed and put into the Fleet the *Sparrow* missile. You might ask "Why have the *Sparrow* if we have an economical and effective *Sidewinder?*" It is not a question of buying a Ford when you already have a Chevrolet. We are faced with the problem of having to be ready for anything and everything which an enemy might bring to bear—and to date no missile does everything.

The *Sparrow* line of missiles is incorporated in air weapon systems involving transonic and supersonic interceptors. In modern task force operations, the fleet's air defense is heavily dependent upon the ability to destroy attacking aircraft at long ranges and under all weather conditions.

Sparrow missiles have added considerable reach to the intercepting aircraft, under blind firing situations, and from a wide variety of firing angles. Further developments underway will give *Sparrow* increased capability for breaking up enemy air attacks at even greater distances, and again under all weather conditions. Both *Sparrow I* and *Sidewinder* are operational.

Many think that missiles will supplant manned aircraft. Be that as it may, it is very clear that in many areas missiles will certainly take over. The Navy attack missile, the *Regulus,* is a good and possibly first example of a missile becoming a partner rather than a tool of conventional aviation. This missile can carry a nuclear warhead and can be launched from ships. In fact, we have ten ships, including submarines, ready now.

The *Regulus* can be best described in the words of Chance Vought, its manufacturer, "It takes shore leave 500 miles at sea." Great mobility in dispersing and in hiding the launching ship in the immense waterways of the world provides a strongly desired element of surprise in the adaptation of *Regulus* to seagoing vessels.

There was a touch of genius involved in *Regulus* when someone conceived the idea of equipping it with landing gear in lieu of warhead during the development program—thus tremendously decreasing the program cost, the development time, and the cost of training. A short while ago at Chincoteague, a *Regulus* was boosted into the air with two rocket motors; then, after a programmed flight, it returned to the base for the fifteenth time.

The supersonic *Regulus II,* which is currently being tested, is also using wheels so it can return to be studied and analyzed and to fly again. It is a pity that we cannot shorten and cheapen all of our missile programs by recovering the spent birds intact.

Missiles also extend and complement the air defense capabilities of ships. Navy missiles devoted to this purpose are the *Terrier,* boosted into flight and sustained by rocket engines; and the *Tartar,* in which a single motor does both the boosting and the sustain-

James S. Russell
Rear Adm., USN

Young (53), energetic Rear Admiral James S. Russell is a man well suited to his job. To intelligent imagination and tolerance he adds a long and varied career in the Navy, including combat duty in the Aleutians, Palau, Philippine Islands, Iwo Jima and Okinawa. Since the war he has commanded some of America's biggest aircraft carriers.

In addition, Admiral Russell has a Bachelor of Science from the U.S. Naval Academy and a Masters degree from California Institute of Technology. He is a fellow of the Institute of Aeronautical Sciences and is vigorously optimistic over the Navy's future in the age of missiles and rockets.

He is intensely interested in the transition from aeronautics to astronautics, and in fact at the recent American Rocket Society meeting in New York predicted that practical nuclear propulsion for space flight would come sooner than we expect (m/r, Dec., p. 29). The Admiral, however, is officially silent on whether the roles and missions responsibility for patrolling the infinite seas of space should fall to the Navy or Air Force.





Out of its deck hangar and ready to go, REGULUS I gets a final check before being launched from the deck of the Navy missile submarine USS TUNNY.

ing. These surface-to-air missiles are quite a bit different from those one sees at our laboratories and testing grounds. There is no count-down, no waiting for computations. One presses a button and in rapid succession and with complete automation, the missiles are fed from the magazines, loaded, and then fired by an electronic device.

The cruisers *Boston* and *Canberra* are now in service firing *Terriers*. We are building our first *Talos* ship to be ready in '58. *Tartar* will be put on ships in the 1957 building program. Five years from now, we will have at least eight *Talos* cruisers, twenty-two *Terrier* ships, and seventeen *Tartar* ships.

Another air-to-surface missile is the *Petrel*, developed by the Navy's Bureau of Ordnance. It is designed to attack ship targets, and combines the features of a guided missile plus underwater torpedo. Attacking aircraft can launch the *Petrel* well out of range of ship defenses without running the gauntlet of conventional flak and machine gun fire.

A large part of Naval air's striking capability is centered around missile-airplane combinations. One of the air-to-surface missiles is designed to give the attack pilot capability to destroy pinpointed targets such as submarines and small shipping. In addition, it has land interdiction capabilities, and can be used in the type of close support work at the front lines, such as knocking out enemy pill boxes and hill-top strong points, which is the particular forte of Naval and Marine aviation.

A new adaptation of guided missiles to air defense is for the defense of large patrol or bomber type planes. Such a missile will have the versatility effectively to seek out fighter and intercept aircraft making runs on the larger Navy airplanes.

Missiles to Replace Bombers

In the basic attack mission of carrier-based aircraft, a general concept is shaping up involving the "stand-off" use of guided missiles. This is anticipating the possibility that the enemy's defenses of industrial and submarine pen types of targets may be so well developed that manned aircraft cannot make a conventional bombing run.

Away from the front lines at sea, or the shooting dynamics of task force air defense and attack missions, a most important work has always been fostered by naval aviation. This is the design and use of target drone aircraft.

The relationship of the automatic airplane to the guided missile is fairly obvious. Guided missiles and target drones are blood cousins. There has been much interchange and two-way flow between the design arts in both machines. This carry-over of knowhow and technique has been of mutual advantage to each.

We in the Bureau of Aeronautics consider the target drone of great importance, first in providing a reasonably fast and maneuverable target for missile test firing and for maintaining combat readiness at sea, and secondly for the techniques in the art of drone design which are applicable to missile design. Although some say that it's not the most glamorous part of the business, the true value of the target drone cannot be overemphasized.

Navy Missile Budget Up

A revealing insight as to the growth of guided missiles and the increasing weight being placed upon them by the Navy is seen by a quick look at the administrative side of the picture. In the past six years, the funding for research and development, test and evaluation facilities, and procurement of flight articles have all steadily increased. The proportion of this increase is much greater than the increase for like considerations of conventional airplanes over the same period. In the fiscal year 1951, the Navy budgeted $5 million for guided missiles. It is estimated that in fiscal 1957 $209 million will be available. This is a rate of increase of almost 21 to one. In conventional aircraft, the increase rate has been roughly only three to one, for the same period.

Perhaps the real proof of the importance of missiles to national defense is the fact that a Special Assistant to the Secretary of Defense was recently appointed to administer the overall guided missile program.

While on the thought of overall administration it might be well to point out that most of the considerations given to guided missiles and rocket applications fit well into the normal scheme of things for those in the airplane business.

Indeed, a thesis could be fashioned drawing out the similarities of airplanes to guided missiles or vice versa in all the design, manufacture and procurement phases. Much of the procedure and knowhow applies in either case.

There are inherent differences, of course. For one thing, the missile can

be designed for optimum flight conditions. Since it has a boost for take-off, and is usually thought of as expendable, the design penalties for carrier take-off and landings, and round trip radii are not there. Neither is the guided missile subject to the ills of the human pilot factor; and conversely, neither does it have the advantages of the human brain.

Military aviation is under constant pressure to maintain or gain advantage over potential enemies. This has forced aircraft up higher and faster, until one enters the true realm of the rocket engine. With a practical air defense mission to perform, the aircraft must have reasonable endurance and meet other design parameters. The manifest answer is to blend the capabilities of the turbo-jet and the rocket engine in a combination power plant.

The future of the unmanned air vehicle in the fleet must be viewed from the vantage point of all these things: the past, those presently operational, and how we manage administratively.

First, we expect to see, as far out as the next fifteen years, an orderly and progressive improvement in all the guided missile types that are now operational. This would mean that basic missions of the guided machine would remain intact, such as air-to-air, air-to-surface, surface-to-surface, and surface-to-air. In all those categories, better guidance, longer range, greater reliability, and more effective warheads tailored to the target will be the trend and the objective.

Secondly, the increased use of guided missiles of better performance will to some extent affect now standard Naval air tactical concepts. The exact extent can only be determined in actual operation at the time and place of a missile's introduction into the fleet.

Then, too, for any bold and sweeping change in fleet air defense, for example, we must look to the enemy's capability. If he comes up with substantial stand-off missile potentials, then we must project our intercept capability to greater distances accordingly. Here longer range air-to-air missile armament for our own interceptors would be in order.

Or, from within our own family, if the surface-to-air capability of our task forces is good, then these missiles will push farther out the fighter and intercept screens, requiring better range in both planes and missile armament.

Mobile Force Immune to Ballistic Missile

At present the Navy is working on development of a 1,500 mile missile which we can call the Fleet Ballistic Missile. I am sure that the ballistic missiles, as well as the earth satellite rocket now nearing its first development flights, *Vanguard,* mean to many of us that the door to rocketry has swung fully open and that we are on the threshhold of space travel.



Research rocket VIKING-13 a few seconds after leaving its mat on a preliminary IGY research flight from Patrick Air Force Base last month. The VIKING reached 125 miles.

To the Navy, entrusted for its part of the National Defense, the Fleet Ballistic Missile fits in another picture. Whether it be a weapon of retaliation or a deterrent to attack, the Navy will be prepared to launch it from an infinite number of locations—at sea within reach of most any potential target in the world. Conversely, the mobility of a Naval force renders it relatively immune from attack by the ballistic missile, leaving the advantages of this overwhelming retaliatory weapon to the Naval force.

Any conjecture as to the possibility of guided missiles taking over the job of task force air defense completely must be tempered by an awareness of the state of the art in missile design. The "when and if" of an all missile air defense is the when and if of a very long range ballistic missile which has the proven capability of successfully attacking moving sea targets.

Should such a ballistic missile appear, it is not unreasonable to anticipate that manned aircraft would give way certainly, for this element of defense, to anti-missile guided missiles.

For the future, the man in the laboratory today increasingly assumes the role of the man behind the gun. More than ever before the outcome in another war would depend on what went on in a test-tube, betatron or the quiet of a mathematician's study three, five or ten years before.

The age of missiles and rockets is the age of the scientist and engineer. Progress in the development of new materials, fuels and design concepts continues to be good, better in some cases than we had anticipated two or three years earlier. The real advances, of course, come with major technological break-throughs as well as in the difficult-but-vital day-to-day development of safe, reliable operational missile systems. In the latter, the Navy has done well. In the case of the former we, the U.S. as a whole, excell but we can always do better by improving cooperation and liaison between three services, other agencies of Government, private universities and industry ★



U.S. Navy Missile Arsenal

Manufacturer	Designation	Powerplant	Remarks
		SURFACE-TO-SURFACE	
Chance-Vought	REGULUS SSM-N-8	1 Allison J33-A-18A jet plus two Aerojet-General solid rockets	In service; nuclear warhead, command or self-homing guidance, subsonic, range over 500 mi.
Chance-Vought	REGULUS II	Prototypes powered by Wright J65; production models get GE J79	In production; supersonic.
Lockheed; GE; MIT	POLARIS	Aerojet solid propellant	Under development; intermediate-range fleet ballistic missile; can be launched from underwater.
McDonnell	TRITON	Zip-fueled ramjet + booster	Under development: supersonic; Mach 3.5; over 80,000 ft.; range 1500 mi.; will fit *Regulus* submarine launching gear.
		SURFACE-TO-AIR	
Convair/Bendix	TERRIER SAM-N-7	Aerojet liquid rocket + solid rocket	In service; beam guidance. Also *Terrier* I and *Terrier* II.
Bendix	TALOS SAM-N-6	McDonnell ramjet + booster	In production; also *Talos* L for AF and *Talos* W for Army. Late Navy developments using zip-fuels to have 300 mi. range; Mach 4.0 speed.
Convair	TARTAR	Allegany Ballistic solid rocket	In production; for destroyers, and other small vessels.
		AIR-TO-UNDERWATER	
Fairchild	PETREL AUM-N-2	Fairchild J44 jet	Under development; anti-submarine missile; launched from aircraft.
Sandia + ?	LULU	?	Under development; air-dropped or surface-launched anti-submarine weapon; atomic warhead.
		AIR-TO-SURFACE	
Eastman Kodak	DOVE ASM-N-4 and -5	?	Under development.
		AIR-TO-AIR	
Douglas, Sperry/ Raytheon	SPARROW AAM-N-2	Aerojet solid rocket	In service; also AAM-N-3 and N-4.
Philco	SIDEWINDER AAM-N-7	Norris Thermador; Hunter Douglas, Hercules Powder solid rocket	In service; infra-red homing. Developed by Naval Ordnance Test Station, China Lake, Calif.

m/r's personal report from . . .

Navy Air Secretary Norton . . .

. . . reveals All-Navy FBM *Polaris* To Be Launched From Nuclear Submarine; Balanced Spending Rise For Navy Missile Program; High Praise for ABMA

Assistant Secretary of the Navy for Air Garrison Norton told m/r's *editor as he sat down for this personal report: "I'm new at the job and really don't have a great deal of experience." His background, however, belies this. Harvard graduate, Certified Public Accountant, reserve Naval aviator and former Assistant CAA Chairman, Assistant Secretary of State, Chairman of the Air Coordinating Committee, Special Research and Development Consultant to the Secretary of the Air Force and U.S. delegate to many international aviation conferences, the Navy's 56-year old Air Secretary has as good a grasp of his responsibilities in his job as anyone we've encountered in Government.* m/r *considers this* personal report *a vital service to the missiles and rockets industry and plans more like it in the future.* The Editor.

Q. Mr. Secretary, what roles do missiles play in the Navy today?

A. The soundness of the planning that we did over five years ago is becoming evident. We now have in service as operational weapons guided missiles in all categories, air-to-air, surface-to-air, air-to-surface and surface-to-surface. In the field of air defense, we have two *Terrier* cruisers. We have just commissioned a *Terrier* destroyer, and we have more surface-to-air missile ships in various stages of completion. These missiles have increased our anti-aircraft range from a few thousand yards to over ten miles. In the realm of air-to-air missiles we have missile-armed fighter squadrons employed in the Atlantic, the Pacific and the Mediterranean. These squadrons are equipped with *Sparrow I* and *Sidewinder.* These weapons increase not only the range at which our fighters can knock down enemy planes, but they permit us to get shots at planes we could not otherwise reach at all, such as those we detect at much higher or lower altitudes. All our air defense weapons are supersonic as they must be to cope with high performance aircraft we may expect to encounter. Anti-aircraft guns are nearly useless against modern aircraft and our airborne guns are becoming very limited in this respect. In the field of offensive missiles we have submarines, carriers and cruisers in both fleets that can launch the *Regulus,* which can carry a nuclear warhead under any weather conditions to targets as much as 500 miles away. The *Regulus,* launched from a submarine, gives us a very powerful capability to attack completely undetected. The *Regulus I* is a transonic weapon, but already we have *Regulus II* flying and that one is supersonic. For attack of surface ships we have the *Petrel,* which when launched by a patrol plane can deliver its payload from so great a distance that the launching plane is not faced with destruction by enemy surface forces.

Q. What about Navy missiles in the near future, say, five years from now?

A. Well, five years from now, we will see very considerable changes in the Navy, not only because our missiles will be faster, more effective and will have longer ranges, but because many of our ships and planes will be missile equipped. In five years, we will have the *Talos* longer-range anti-aircraft weapons in many ships. We will have the *Intermediate Range Ballistic Missile,* the FBM, in operation. We will have vastly improved missiles in all other categories.

Q. You mean to say the fleet ballistic missile will be in operation within five years?

A. That's what we expect.

Q. From submarines as well as surface ships?

A. Well, we have hopes it will be operational off submarines in that period too.

Q. Will you have to build new submarines for that one or can you use existing types?

A. No, we have to build new submarines for the ballistic missile.

Q. That's an acceleration of your program, isn't it? You must have gotten more optimistic quite recently.

A. Yes, we have reason to feel that we are closer to an operational Fleet Ballistic Missile now than we felt we were a year ago.

Q. In that connection, Mr. Secretary, just how does Defense Secretary Wilson's November 26 "roles and missions" Memorandum affect the Navy's ballistics missile program? Does this mean that the Navy will give its FBM development to another company or to a private agency? Or will the Navy continue to work with the Army Ballistics Missile Agency (ABMA) and Jet Propulsion Laboratories in this project?

A. Secretary Wilson's memorandum of the 26th of November of this year applied primarily to the roles of the Army and the Air Force. It restated the policy of Navy employment of all categories of missiles, including the Inter-

mediate Range Ballistic Missile. The Fleet Ballistic Missile has requirements that are unique to the Navy. For example, submarine-launched or underwater-launched weapons have special problems, as you can well imagine. Because of the proximity of crew to launching platform we need safer and extremely reliable missiles. Restrictions as to space and size of our ships affect missile design and of course we have very strange navigation requirements. During the past year and a half the Navy has been studying these missile requirements. As a result of these studies the Navy has now revised its program objective. It is still too early to define the contractual structure that the Navy may employ in this revised program.

Q. The revision that you mentioned indicates that the Navy will go out on its own, rather than work with the Army.

A. Yes, that is correct. However, the Navy hopes to make fullest possible use of the ABMA Huntsville facility. As you know, there's great talent there and we have good hopes of running certain parallel approaches in our programs.

Q. You might give them a contract, then?

A. Yes, but basically the Navy is now free to approach this problem on its own.

Q. You don't contemplate that ABMA will be dissolved then?

A. No. We don't know what the plans are for ABMA, but we do know that it is the intention as far as fiscal '57 money is concerned to carry on the present *Jupiter* program, and we certainly hope that the very real talents and ability available there will continue to be available in some form because we think we can make good use of them.

Q. As of now, then, there is no joint Army-Navy *Jupiter* program?

A. That's correct.

Q. Is the main reason for this the technological differences in the missile itself?

A. Yes, I would say so. What we want is a device that is operational when we get it. We want one we know we can go to sea with and use. There have been breakthroughs in this business, and we have now come upon a configuration which looks very good to us, and which is compatible with sea-launching from both surface ships and submarines. This missile has been named *Polaris*.

Q. You mean under-water launching?

A. Yes. That is a possibility.

Q. Dr. Murphree confirmed some time ago that the Navy was interested in a solid propellants Fleet Ballistic Missile.

A. Yes. There are obvious advantages to it.

Q. Are missiles entirely supplementary in the Navy today, or have they begun to replace other weapons types, such as big guns?

A. The position of missiles in the Navy today is very clear. We are committed to converting the Navy to nuclear propulsion and guided missiles for a large number of our tasks. This, of course, takes time and money, but in order to effectively accomplish our mission we must continue this effort with high priority. It would not be accurate to say that missiles play only a supplementary role, since they are able to do many things which other weapons cannot do. In some cases they will supplement, and in other cases they will replace current armament. However, until we are able to complete the conversion of the Navy to missiles, we will see the old weapons side by side with missiles for a number of years. Guns are being replaced, especially for air defense. In addition, certain of our surface-launched air defense missiles will soon be given the capability of hitting targets on the surface as well as in the air. Then the need for surface guns will be very small. We are already planning missile-only cruisers.

Q. Have you stopped buying big guns—heavy rifles such as 16-in. guns?

A. As far as I know we have, yes.

Q. This applies to aircraft carriers as well as other surface ships?

A. Well, I do know that missile anti-aircraft defense is definitely contemplated for our carriers.

Q. You won't see carriers coming off the ways with 5-inch, 38-cal. guns sticking out of the side?

A. I think those days are numbered. Missiles do pose some structural problems. You've got to have little bigger spaces for the missile launching area and devices than you do for the guns. The question of arming our carriers with missiles may still be one that is not yet fully decided. In other words, there may be some advantages in having missile defense on cruisers and so on, around the carrier itself, although I would think that the carrier would be bound to be equipped with some anti-aircraft missile defense. But the mounting of the missile battery is not necessarily the same problem as the gun battery. Of course, a carrier, as you know, is such a specialized affair and every inch of space on it is so important, both on the hangar deck and on the flight deck, that there is still some question as to how far they go in missile launching on carriers themselves.

Q. Looking into the future a bit, how will roles and missions, tactics and strategies of Naval warfare be changed by the advent and development of whole families of guided missile types? For example, insofar as strategic missions are concerned, do missiles presage the day when the surface carrier groups will be superfluous as a strategic concept? Presumably it will be tactically important for some time.

A. This is looking at the future. The basic mission of the Navy is to control the seas and the air above and adjacent



In five years . . . an operational POLARIS.



We need safer, more reliable missiles.



No joint Army-Navy IRBM program any more.

to the seas. You mention both strategic and tactical missions. I would like to point out that the U.S. Navy has a very important requirement to maintain a strong element of air power capable of conducting strategic bombing of not only sea targets, but land targets of Naval interest. Therefore, carrier air groups will be required for a long time, backed up by land and sea based patrol and heavy attack aircraft. In the event of a non-nuclear war the use of missiles for bombardment purposes will be far less than in a nuclear war. The higher degree of accuracy necessary in non-nuclear war will make the Naval air-striking forces indispensable in any such conflict. In nuclear war, it must be remembered, that all land bases will be extremely vulnerable to enemy attack by long-range missiles, enemy bombers, or sabotage. A mobile task force, in a position which is unknown to the enemy will be a much more difficult target to knock out. It might well be that the carrier task force would be our greatest retaliatory force in the event of a surprise enemy nuclear attack.

Q. The beginning of the incorporation of missiles into the Navy on a wide scale must be raising a number of rather worrisome problems: for example, stability in the trained military work-force. The cost in turn-over (failure to re-enlist) must be much greater in the age of the *Regulus, Terrier, Triton,* etc., than it was in the day of the gun. Does not this become increasingly true now that industry's need for men with the same training is so great? How does the Navy view this problem? What's it doing about it?

A. The introduction of any new weapon or any new device always creates a host of problems. The problem of manpower that you mentioned is a great one to the Navy as it is for all the services. In the Navy we strive to develop missiles which can be operated by our sailors. We have succeeded in this to a large degree. We have no contractor's representatives or PhD's on any of our missile ships but we do need a very high level of skill among our enlisted men. It is remarkable how competent some of our Navy men can become. This, of course, is recognized by industry and we do have a competition problem. Recently the Navy has instituted career appraisal teams that have shown results in pointing out to our men the advantages of making a career out of the Navy. We also hope that some of the studies being conducted on military pay and manpower by groups such as the Cordiner Committee will help us in this problem.

Q. Are there any special logistical problems posed by missiles? If so, what are they? What can industry do to help solve them?

A. The logistic problems that accompany the introduction of missiles to the fleet are not unique but are similar to problems faced with aircraft, electronics gear and other complex machinery. The replacement of missiles at sea pose many technical problems that are being successfully worked out. I might add that the aspects of handling, resupplying and supporting a missile are not neglected until the time we get the missile to the fleet. These factors are given considerable attention from the very inception of a missile program, and problems relating to packaging, maintenance, resupplying, so forth, are solved as the missile is being developed. Industry has been concerned with these items concurrently with the evolution of the missiles.

Q. Would you conceivably reach the point where you would be transferring missiles to ships the way you now transfer oil? In other words, pull a supply ship right up alongside and, under way, sling them across?

A. Oh, I think that is not only entirely possible, it is mandatory. I think the ruggedizing of these missiles, for example, is one of the main features. I happen to be acquainted with the *Terrier* development. That's a remarkable case in point. That missile, when it first became operational was still a very delicate affair which had to be handled with great care. Now, thanks to the use of potting compounds in the missile itself plus much more rugged components, the missile can be handled almost the way you handle a five-inch shell. And this will probably be the general trend. It usually is.

Q. Would you say this concept will apply to all kinds of Navy missiles, the larger one as well as smaller surface-to-air missiles?

A. You mean the concept of making them more rugged? Yes, indeed. We are, of course, trying to produce a weapon here that has a long shelf life and that can be handled under sea conditions, under battle conditions and that can be handled by sailors. All of these things require tremendous inherent reliability.

Q. Do you have any special facilities for inactivating shipboard stores of missiles? All these propellants, which are highly explosive seem to constitute a considerable hazard. Do you have, for example, any special arrangement for dumping these things in case a ship gets hit?

A. I just don't know the answer to that. I should think that it might conceivably be that we at least would have to make arrangements for flooding things.

Q. Are they stored the way you used to store your aviation fuels, in a shell of inert gas?

A. We are trying to get away from these exotic and difficult fuels that require special handling. Of course, liquid oxygen is a dreadful thing to handle under any circumstances, particularly so on shipboard. If you have a good reliable solid propellant that can be stored in the same environment with conventional high explosive, etc., you would still be in pretty good shape, I would think.

Q. Aside from absolute, no-defense weapons like the ICBM, it seems that special evaluation procedures must



Red submarine threat cannot be exaggerated.



In some cases . . . no choice but missiles.



My guess is the dollar curve goes up.

be required to determine when a missile weapons system is "worth more" than a conventional weapons system. First, servicing and firing costs would be one yardstick, for example. Has the Navy formalized this relative evaluation procedure? Can you say in general terms what form it takes?

A. Before answering this question, I would like to take exception to your "no-defense" statement concerning the ICBM. This is an extremely difficult problem, but we are working on it and don't forget that the mobility I mentioned before gives a fleet an all-important passive defense to begin with, in that a moving object is not a suitable target for a ballistic missile. The question of evaluation is extremely important not only from the point of view of costs but from the point of view of whether or not the new weapons system meets the requirements. Let me briefly outline how the Navy gets a new weapons system. First, an operational requirement is issued by the Office of Chief of Naval Operations calling for the development of a certain type of device. This is done only after exhaustive consideration of the problems by both Naval officers and various study groups, either agencies of the Navy, such as the Operations Evaluation Group, or organizations under contract to the Navy. Secondly, when this operations requirement is issued to the technical bureaus telling them what to produce, the bureaus themselves have continuous evaluation programs during and after the development of the weapon. Finally, when the missile is ready for production, it is turned over to the Operational Development Force, which is a fleet unit. This force gives the missile a rugged test under actual fleet conditions but with better evaluation facilities. All these evaluation processes consider costs, manpower required, use of vital materials and so forth. We never build missiles just to have missiles. They must do a certain job and do it better. In some cases, however, we have no choice but to adopt missiles such as in the case of the anti-aircraft missiles I mentioned previously.

Q. Can you give us some idea, Mr. Secretary, just how, over the next few years, the advent of missiles will effect the various titles under Category II (military hardware) procurement? We'd like not only to get some percentage idea of how missile procurement will increase, but also how other things like manned aircraft, surface ships, submarines, electronics, big guns, etc., are expected to vary.

A. This is a question I can answer only in general terms at the present time. I can say that the missile procurement will increase over the next few years. Procurement of weapons displaced by missiles such as anti-aircraft guns will obviously decrease. Weapons supplemented by missiles may decrease in number. Within the available funds, as determined by higher authority, we will do our best to procure and maintain the best balanced force possible for carrying out the Navy's missions and tasks, At the present state of the art, there are too many variables involved to state the exact form that such a force will take.

Q. Air Force estimates 35% of their budget will be for missiles shortly. How does the Navy compare?

A. I'm fairly conversant with Benny Schriever's activity in the Western Development Division and what's involved there alone. And it's a fantastic effort. Of course, there you have the entire ICBM program and one of the ultimate IRBM programs. I would think that at least over the immediate future, the next two or three fiscal years, that the Navy's missile percentage would not be as high; however, you do have to look down the road a little bit, and you come to the submarine missile program, which is an IRBM program. Taking submarines and missiles altogether, they will represent a very substantial percentage of the Navy's total money. The Navy is working along, you might say, a triple threat program here, of seaplanes, missile launching submarines and fast carrier task forces, and I would think that looking further into the future, it is unlikely that any one of those programs would be more than a third of the total over a period of years.

Q. Will the FBM subs be atomic submarines?

A. Yes, nuclear propelled.

Q. Just looking at the budget generally, looking at missiles, their striking power, or whatever term you want to use—do you think you will get more punch per budget dollar? Or do you think your budget is going to go up sharply also?

A. That's a very hard question to answer. It is one that Bob Lovett was greatly interested in when he was Secretary of Defense. He had a number of studies cranked up to try and find out whether we were heading into a fantastically high military cost, as some people said, or whether we were actually, by virtue of all the new developments, coming to a point where the curve would go down. My general impression is that the curve is going up and will continue to go up. The complexity of these weapons is so tremendous that even though one weapon can deliver, for example, the entire explosive force which was exerted in World War II, it doesn't follow that you reduce your defense dollar. My personal view is that the defense dollar will continue to increase as long as we have to have defense dollars at all.

Q. Will missiles alone have any material affect on the number of men under arms, all other things being equal?

A. I believe the introduction of missiles to the fleet will have negligible effect on total manpower requirements in the Navy. If we resort to weapons of greater efficiency, we may possibly need fewer fire control units. However, the complexity of the missile systems may require a few more people. In effect, I see little change in total numbers, rather, a reorientation in the employing of our men. Our problem is one of highly-trained, competent personnel.

Q. In other words, you can't say you're streamlining the Navy, like the Army is, because of these new weapons; that won't apply to the Navy?

A. It certainly will apply in the sense that you have fewer numbers of ships . . . That's logical, if the fire power of one ship is equivalent to the fire power of a hundred ships that we had in World War II—well, there are chances that we have fewer ships. The same is true of aircraft. The same might very well be true in numbers of missile launchers compared with 15-inch rifles and so on . . . but the dollar is another story. My guess is the dollar curve goes up.

Q. I'd like to throw in a final question, if I may . . . about the Russian submarine threat. Supposedly, they have 400 submarines and supposedly they have been building missiles for their submarines. Do you feel that the Russian submarine fleet is as great a threat as has been indicated in the press lately?

A. I don't think you can exaggerate the threat. The number of Russian submarines is somewhere between 500 and 600. They are producing submarines at the rate of two new ones every three weeks. They are concentrating, for the most part, as far as we know, on the so-called W-class submarines which are the long-range submarines capable of operating in the Western Atlantic, for example. We have no reason to think that the Russians are not also working hard on nuclear propelled submarines and missile launching submarines. We feel that the Russian submarine threat to the United States, as I say, cannot be exaggerated.

Q. Do you think that the Russians are ahead of us in missile launching submarine development?

A. We'd like to know much more about the Russian submarine fleet than we do, along with the rest of the Russian military effort. Personally, based on what I have heard, I'm inclined to think that we are ahead of the Russians in submarine construction and in missile launching capability in submarines.✶

Need for Space Flight Know-how

Vital Unknowns of Flight Beyond the Atmosphere Can Only Come from New Research Methods

By Cdr. George W. Hoover, USN

Behind the production of ships and planes and weapons is a vast research and development program. Paralleling this type of research is an almost equally large program to keep the fighting men alive, not only in the face of enemy weapons, but against the adverse effects of nature as well.

These adverse effects are some of nature's stumbling blocks placed in the path of man's progress, such as his conquest of high speed, high altitude flight. The results of this type of research are not only advantageous to military knowledge, but are equally effective in the advancement of civil aviation. This is particularly true now with the advent of jet transport aircraft, and will be even more so as aircraft begin to fly beyond the atmosphere.

Out of these research programs have come many test aircraft, each a little faster than its predecessor and each capable of reaching a higher altitude.

In August 1947, the Douglas Skystreak set two records at Muroc, California; the first 640.7 mph and the second five days later, 650.6 mph. December of 1947 brought forth the Bell X-1 which set several records in excess of the speed of sound.

Douglas came back in August of 1951 with the Skyrocket, D558-II, which established a speed of 1238 mph and an altitude of 79,000 feet. In August of 1953 this record was exceeded by the same Skyrocket which reached an altitude of 83,235 feet and in November 1953 a new speed record of 1327 mph was made.

The Bell X-1A followed the Douglas flights by setting a record of 1650 mph in December 1953. The X-2, the successor of the X-1A crashed in September 1956, but not before setting records of over 2100 mph and an altitude of 126,000 feet. Recently the announcement was made of a new research aircraft which will be capable of even higher speeds and altitudes.

As you can see from the record, man is definitely outward bound—but not before some means is developed to give us the vital answers to the multitude of unknowns required to make manned space flight possible.

Technological advances in power plants and in aerodynamics have indicated that aircraft capable of carrying men completely beyond the earth's protective atmosphere are not only feasible but probable within a very short time. One feasibility study, made to determine the possibility of an aircraft capable of such performance, indicated that altitudes in excess of 500,000 feet were possible with speeds approaching 4,000 mph. Such an aircraft could be used to study methods of re-entering the atmosphere, study insulating coatings, provide experience in space flight, and stimulate development of better rocket engines.

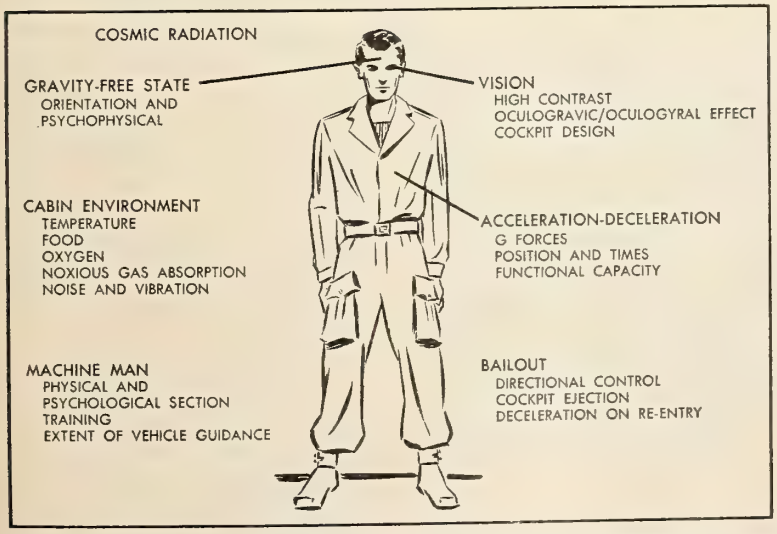
Many Problems, Little Data

Further studies have indicated that not only are there many problems, but that very little data is available in many of the critical areas.

As an example, in the field of Geophysics and Astrophysics the problems of protecting man and his machine are relatively unanswered. Solar radiation will affect the structures and materials, the instrumentation, and the man himself. Cosmic radiation effects must be neutralized. Meteroids will cause damage to the machine by surface effect or direct collision. The chemical state of the atmosphere will affect structures, radio communications, aerodynamics, and will create problems due to the accumulation of charge on the machine. Winds and turbulence will raise problems in the guidance and the stability of the craft.

Each of these problems must be studied by actually measuring the effects in order to determine methods of preventing damage to both the machine and the occupant.

In the field of Aeromedicine similar problems must be studied. There are problems of living in a gravity-free state effecting orientation and those of the psychophysical condition of the man. Cabin environment must be studied in order to be able to maintain proper temperature, oxygen supply, noxious gas absorption, noise and vibration, and sufficient food for the crew. There must be



Some of the new environmental conditions to which man will have to adapt himself or from which he will need protection in space.

provision for control during emergencies, escape from damaged vehicles, and safe deceleration on re-entry.

G-force position and time, as well as total capacity must be studied to answer the problems of acceleration and deceleration. Effect on vision due to high contrast, gravity and gyroscopic action must be understood in order for man to operate efficiently. The man-machine system must be studied to determine the physical and psychological requirements, the training requirements, and the extent of required control.

Here again in this field a means must be developed to obtain the information necessary to make man's existence in space possible. And not only in this field, but in Guidance and Control, Communications, Propulsion, Auxiliary Power, Structures and Materials, Aerodynamics, Re-entry, and Launching and Landing. In all of these fields, many tests and evaluations must be made before sufficient knowledge will be obtained to try manned flight into space.

As a matter of fact, present studies indicate that in the field of Guidance and Control, we know about 40 per cent of what we should know in order to send a manned ship into space. In Communication we know about 60 per cent of what we need. In Aeromedicine we have less than 10 per cent of the required knowledge and in Launching and Landing we know practically nothing. In other areas we are about as badly informed. This is not because we are not looking for answers, but because there has been no way to obtain the required knowledge.

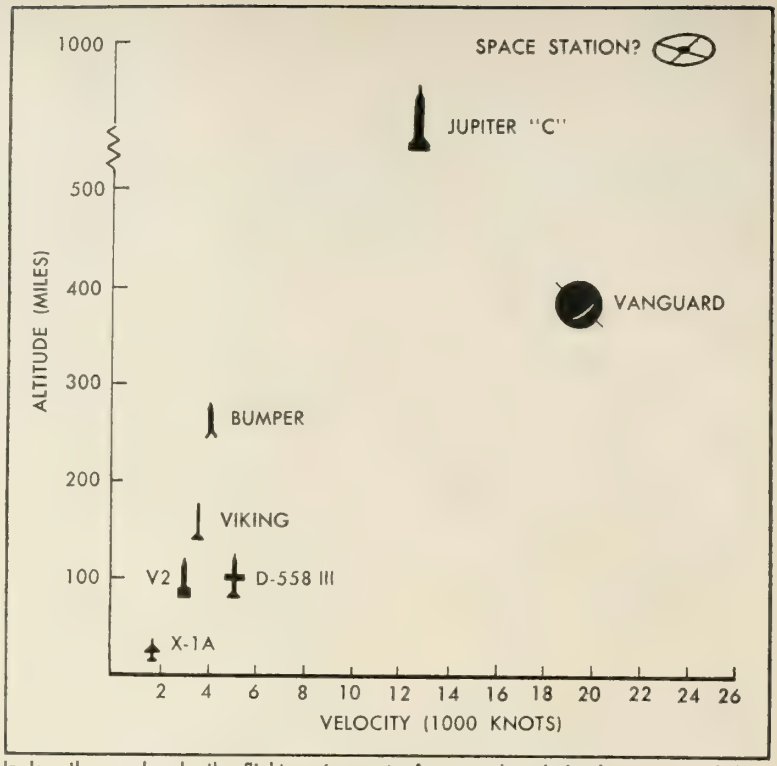
New Research Tools Needed

Present methods of gathering research data are inadequate. Ordinary aircraft cannot fly high enough to measure the environment in which these aircraft of tomorrow will operate. Rocket powered test aircraft, although having the capability of achieving extremely high altitudes and speeds, can only gather data for seconds of time. This is due to the short duration powered flight.

Even high altitude rockets, capable of attaining extremely high altitudes can only provide minutes of data gathering, and then only for a few answers at a time. With the number of answers required, this becomes a rather expensive method of obtaining the necessary information. High altitude balloons, although capable of remaining aloft for hours at a time, can only reach the top fringes of the atmosphere, beyond which lies most of the unknowns.

In other words a means must be utilized which will give long periods of measurement time at extremely high altitudes at very high speeds.

New research tools must be developed which meet these requirements, and these research tools will be satellites.



In less than a decade the flight environment of man-made vehicles has progressed from subsonic and under 100,000 feet to Mach 19 and over 650 miles up.

Not just one, but a long series of satellites, each gathering more and more information, until all the answers are obtained. Actually the satellite is not an outgrowth of Science Fiction, but is just a logical step in a very normal research program, the results of which will be beneficial not only to our nation, but to the entire world. A satellite is the only space research tool capable of being developed at this time to permit man to learn more about himself, the world, and the planetary system in which he lives.

In addition to the basic scientific data which will be gained from the early satellites, more and more instrumentation will be included as the satellites are enlarged, and information will be gathered in order that man can learn how to penetrate space and return safely.

Studies of the launching techniques of the satellite missiles will give us necessary information as to the acceleration forces to which man will be subjected in his take-off from the earth.

The trajectories and paths of the satellites as they enter their orbits will tell us much about the control which will be necessary in order to place a manned ship in its orbit. Much will be learned about the problem of placing two vehicles in the same orbit, for rendezvous in space will be considerably different than in the atmosphere. In addition to these data, information can be obtained to determine the man's share in operating the equipment and the amount of full automation required.

Launching a series of satellites will tell us what we need to know about power requirements, not only for propulsion, but internal power as well.

The relay of information will test existing communication techniques as well as define the requirements for new methods. The use of digital techniques, data links, television, and methods of relay are only some of the many experiments which can be carried out.

Medical experiments will undoubtedly be of top interest in the early satellites. The effects on human beings can be extrapolated from telemetered data as well as from the recovery of animal subjects. Almost every part of the satellite and launching vehicle can be used in the aeromedical aspects of space flight. Later satellites will be returned to earth through the use of retro-rockets, drag techniques and parachute devices. These will give us the answers to the re-entry problems and the return and landing.

Man will fly into space just as the Wright brothers flew the first aircraft. The satellite will show us the way—first unmanned, then manned, and finally orbiting observatories and space stations.

[*Opinions expressed in this article are those of the author and are not to be construed as official or as reflecting the views of the Navy Dept.*]

IAF AND UNESCO

Formal recognition of the International Astronautical Federation as a consultative Non-Governmental Organization (NGO) of the United Nations Educational, Scientific and Cultural Organization (UNESCO) now seems virtually assured.

A two year delay in final action, however, appears to be unavoidable. Progress to date is due mainly to the efforts of Andrew G. Haley, General Council and a Director of the American Rocket Society and Chairman of the International Affairs Committee of the IAF.

Once space travel becomes a common thing, almost from the first of manned space flight in fact, a number of thorny international legal problems are bound to arise.

These include flight over sovereign territory—how high is up—problems of radio channel allocation throughout a wide range of frequencies; satellite navigational control; weather monitoring, etc.

It is obviously desirable that the machinery for sorting out these problems be in existence before they occur, rather than have to be jerry-rigged afterwards. It also seems desirable to set up this machinery in already-recognized, established international bodies.

For this reason, there has been a considerable effort during the past few years to link up the IAF with the UNESCO. Recently considerable progress has been made.

Elected at last September's Rome meeting of the IAF as that organization's official delegate to the 9th General Conference of UNESCO in New Delhi, Mr. Haley spent two weeks last November in India pushing for consultative status for the IAF.

IAF feels that with manned space flight now assured in the proximate future a proper grounding now for UNESCO will prevent a lot of headaches later. Mr. Haley's reputation is as one of the country's foremost authorities in the growing field of space law.

UNESCO Status Voted IAF

In New Delhi, NGO cooperating status for the IAF was motioned by Prof. Shemuel Sambursky, delegate from Israel and personal friend of Mr. Haley and Dr. Theodore von Karman. About a dozen organizations were proposed for membership in this category. All were approved in one vote by a small margin.

Mr. Haley reports that one of the biggest stumbling blocks has been UNESCO's inability so far to agree on the conditions of NGO status. It was for this reason that on the day following the vote for admission, this action was revoked. Mr. Haley, having departed India on the evening of the first vote, Prof. Sambursky carried on the fight. In a letter, he writes:

"In spite of this reversal, I took the question up in the program commission under the chapter, Cooperation with International Organizations of the Natural Science Department. I formally moved that UNESCO's Secretariat study the possibility of cooperation with the IAF, especially of consultation between UNESCO experts and the scientific committee of the IAF on all the problems of space flight and astronautics. Prof. Pierre Auger (Assistant UNESCO Director) was asked by the Chairman what his attitude was, and he replied in the affirmative, whereafter the matter was passed without opposition."

Preliminary negotiations are now under way for working out areas of cooperation between IAF and UNESCO. The former has agreed to bear the costs of these early studies, if necessary. It seems that by the expiration of the two year delay now required for any new admissions, most of the groundwork will have been completed.

In this connection Mr. Haley says: "The inauguration of the program in a peace and uncomplicated manner is a great achievement of scientists throughout the world."

On his way back to the United States, Mr. Haley stopped off in Athens, and there gave a lecture on the current problems of astronautics and showed movies of developments as the dinner guest of King Paul and Queen Fredericka of Greece.

The Queen, Mr. Haley reports, shows great interest in the field, along with her brother, Welf Heinrich, Prince of Hanover. The latter, like Mr. Haley, is an accomplished authority on space law. Other guests at the dinner included the Chiefs of Staff of the Greek Armed Service, the Minister of Defense, U.S. Ambassador George Allen and other embassy officials.

Films Draw 700

One showing of these films in Paris drew an audience of more than 700 people which, Mr. Haley suggests, is a good measure of the growing interest throughout the world in the field of astronautics.

The ARS director's films are currently being shown in other cities throughout France under the auspices of the French Astronautical Society, whose President, General P. Bergeron, plans to visit the U.S. during the latter part of January.



Internationalist Andrew G. Haley and Soviet space man Leonide Sedov at last September's Rome meeting of the International Astronautical Federation.

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EDUCATION . . .

. . . for the Missile Age

How different the criteria?

How different the curriculum?

By Kurt R. Stehling
Head of Propulsion,
Project Vanguard
Naval Research Laboratory

IT IS OBVIOUS that education begins in the primary grades. It is perhaps not so obvious that the inspiration of the teachers and the quality of the subject matter taught in these early years are the mainsprings for the responsiveness and interest of a young person in the very important later high school and university years.

There is presently a great furor in this country about the lack of teachers, school physical plant, and money to pay the one or build the other. We have the paradox of a society composed of taxpayers who piously wish for these elements of education, but who are not willing to pay. Instead, they pour billions of dollars each year into vast amounts of "necessary" commodities, such as liquor and automobiles.

Educators and teachers are faced with the prospect of bringing up and educating the maladjusted offspring of those taxpayers who, in most cases, should be doing at home much of the upbringing left to the schools.

The great missile age is about to descend upon us. This will demand a generation of young people trained in the fundamentals of science and ancillary subjects. These very subjects are often bypassed in the frantic scramble to process every pupil as fast as possible through the school mill.

All this is enthusiastically endorsed by the parents who do not wish to see their progeny burdened with any intellectual exercises. Universities, especially those in the upper ranks of scholarship, often have difficulty in adapting their students to the rigorous curriculum which these good universities demand.

Those students who wish to enter the field of guided missile technology must be prepared to have a good grounding in physics, chemistry, and mathematics. They should not have their thought processes cluttered with too many generalities—liberally spread on by technical colleges who believe a student's education is directly proportional to the total number of technical subjects he has studied.

Industry Must Share Burden

However, it must also be said that industry, particularly the guided missile industry, must share the burden of inspiring and training young people for this very complicated business. So far, industry has played only a meager part in this scheme, although many industrialists are the first to scream about the lack of engineers and physicists.

Yet, the aircraft, missile and component industry is partly responsible for this shortage of scientific workers:

1—Industry lets the schools do all the educating without much "on-the-job" training. The supervisory and managerial personnel, often haphazardly and sloppily trained in their functions, are busy empire building. They cannot, even if they wished, take a young person and lead him through the jungle of paper work complexities which cover the average engineering department.

2—Cost-plus contracts and empire building seem to favor the sucking in of "bodies" (a cynical generic term now widely used) without fitting these "bodies" into a proper niche and making the best use of them. Therefore, we often have three people doing the job of one. Meantime several other extras must undo the miasma of wasted effort introduced by this last useless group.

3—The same situation has the further effect of permitting industry to raid the staff of the very universities which supply the graduates industry needs so badly. The attitude is "Let's hire a few PhD.'s to build up our personnel roster on contract proposals." Many of the universities, therefore, have difficulty in maintaining their staffs, especially with the better people who have made names for themselves through publication and research. Those men who have been seduced from their campus positions by the lure of greatly increased salaries are often thrown into the wilderness of industrial operations without being especially fitted for this atmosphere.

Conflict Tough To Solve

There is nothing wrong with the premise that our technical colleges and universities should serve industry and the community at large. And they must maintain their contacts with industry if they are to sustain a fresh viewpoint.

What is wrong, however, is the hiring of these research workers and scholars on a full-time basis, thus killing the goose that lays the golden egg. Again, this would not be so bad if these teachers found themselves in an amendable environment; but since many are first and foremost teachers, their best talents are not compatible with the fast-moving requirements of industry.

What then is the answer? Should the universities try to raise salaries to industrial levels? Should they permit more outside consultation by the faculty? Or should they encourage industry to build research centers on the campus to enable the faculty to work in two places at once?

In the case of the first question, it must be obvious that most universities in U.S. have neither the endowment nor

wherewithal to pay industrial salaries. A few of the wealthier institutions could, perhaps, approach this by reducing the faculty and accepting more government or industry-sponsored research, and an increment above academic salaries.

Indeed, many technical institutions are so loaded down by outside contracts, usually government, that the scientific faculty in its eagerness to make a little more money spends as much time working on these sponsored contracts as on teaching. Yet teaching should surely be the prime objective of a university. Incidentally, a very undesirable by-product of research is the inequity which is produced in faculty salaries in an arts and science institution. After all, the professor of ancient history, arts, English, philosophy, etc., can hardly expect a research contract which will increase his regular salary, although an altruistic government agency will sometimes hand out such a small research contract.

Of course, the arts faculty ought to live with the ugly realization that it has no industrial salary scale to live up to since industry is not yet in the habit of hiring historians, philosophers, and students of English, although it ought to begin to do so.

The second question asked was "Should the faculty be allowed extra consulting time to implement their salaries?" This, of course, is widely done at present and is perhaps the least painful way to aid the industry and u n i v e r s i t y through the feedback so obtained. However, the amount of consulting can easily become excessive and too often transcends into a full time job in industry.

The last question, i.e., whether universities should permit the building of engineering research laboratories on the campus, can be answered by pointing out that this is presently happening at such institutions as Massachusetts Institute of Technology, University of California and University of Chicago. There is no question that the campus atmosphere attracts many missile engineers who think fondly of their college days and often tire of industry's pace.

Several missile firms, such as Lockheed, have taken advantage of this recognized feeling by moving research labs close to a university campus. At the same time they have the advantage of the proximity of a scientific institution with all its resources of faculty, laboratories, and libraries.

Missile Age Demands a New Man

The missile age will demand a new man. He must be educated not only in the superficialities of college curriculae, but he must be grounded in the fundamentals of physics and other branches of science and mathematics.

We tend to produce today an overtrained engineer who is only partly educated. The ability to write a clear and concise report, the ability to reach the fundamentals of a problem without a great crowd of redundant material is an important one. The growth towards specialization is becoming an obsession.

Many young engineers, and old ones too, are afraid to express themselves in a field other than their own narrow one. There is open jealous compartmentalization of the various enterprises on missile projects. The top missile engineer should be encouraged to cut across party lines and make contributions where he can—whether it be propulsion, guidance and control, structures, electrical and telemetering or dynamics.

Some of these fields, such as solid-state physics, metallurgy and cryogenics, are often neglected or underpopulated—both at the university level and beyond—because many students take the easier and more glamorous courses. Yet metallurgy, for example, is becoming a crucial factor in this age of super-jet engines and high pressure rocket engines and gas turbines.

Another interesting area with great potential is that of ceramics. Only two or three universities in this country have the study of ceramics as an undergraduate and graduate specialty. The missile age will demand trained and experienced men in such areas as ceramic rocket thrust chamber design, aerodynamic-heat resistant coating, "cermets" and ceramic coated turbine blades, acid resistant coatings, etc.

If a typical missile is divided into its major domains it is possible to point to either a major course of study required or to the kind of engineer who is doing such work or who should be.

It is not yet apparent whether the complete missile engineer of the future will be a finished product of some missile engineering curriculum or whether he will, as at present, "grow" into the job. Although some universities have missile engineering courses as part of an aeronautics curriculum, industry is presently fitting non-aeronautical engineers into many positions which may some day be filled only by recognized missile engineers.

The missile engineer of the future will need a thorough grounding in only the fundamentals of physics, mathematics and chemistry. He must have a sense of dedication and enthusiasm and an awareness of the mighty potential of missile technology—space flight. Then will he be an astronautical engineer. ✶

[*Opinions expressed in this article are those of the author and are not to be construed as official or as reflecting the views of the Navy Dept.*]



Seventeen-year-old rocketeer Jimmy Blackmon receives advice on propellant flow from some of the nation's top rocket engineers at the American Rocket Society annual meeting. Jimmy had just received the $1,000 Chrysler Corp. award for his basement-built rocket. "Now I can go to college," he said. Chrysler is to be congratulated for instituting this annual award, for if the shortage of engineers is critical in aviation, it's catastrophic in the missile industry.

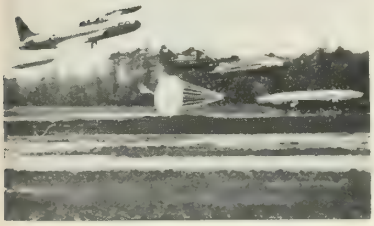
Versatile Regulus Now Operational



Factory checked, canned Chance-Vought Regulus leaves Dallas for parts unknown.



A big bird and quite conventional, this atomic missile is ready for war today.



Drag chute flares as chase planes guide test/training Regulus to safe landing.

At first glance, the Chance-Vought *Regulus* is a very ordinary unsensational missile. It's a nine year old program. So it's not new. It's an air-breather; is subsonic; and has a range of well under 1,000 miles. But there its plainness ends.

This undramatic approach to the very dramatic postwar business of guided missiles is paying dividends with interest compounded. For example:

—It is fully operational, can deliver an atomic warhead over 500 miles away under any weather conditions.

—It works as well on land, surface ship or submarine.

—There are even unconfirmed reports that it has been tried as an air-to-surface missile in tests from a B-52.

—In the fleet the on target success probability of each launch is 0.91, which must be some kind of record for a medium range missile.

—Guided Missile Group II at Chincoteague, Va., has completed over 100 launchings since it was formed in September, 1955.

—And in most of these cases the bird flew home and landed to be studied and used again, because training and testing versions carry retractable wheels instead of an explosive payload. This compares, for example, to the $70,000 that's splashed every time a *Matador* is launched.

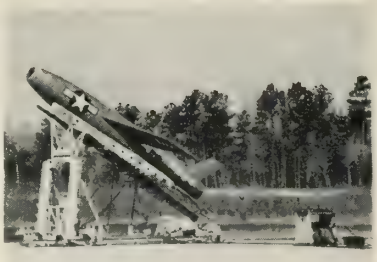
—Initially guided by a chase plane, *Regulus* can now also be ground directed to its target and will soon be equipped with self-homing equipment.

That's *Regulus I*, the Navy's fully operational medium-range surface-to-surface missile.

Now *Regulus II* is flying (see page 42 for artist's conception). Soon

Below—Wings tucked in, Regulus reports aboard submarine to make lethal team.





The Marine Corps should be happy that Navy's over 500-mile missile . . .



. . . works as well on land as it does at sea as this picture series of a . . .



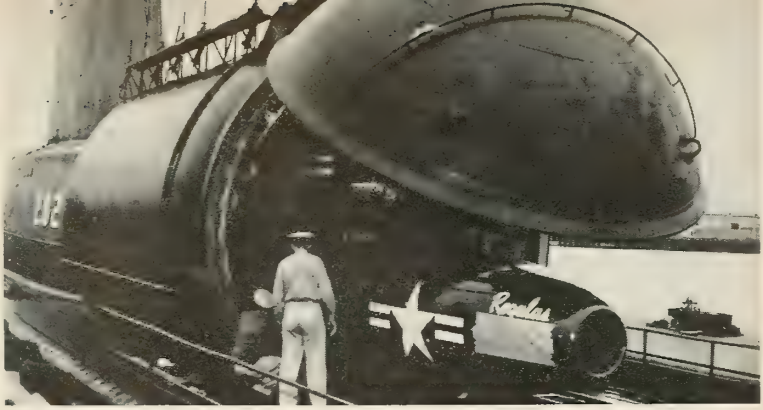
. . . JATO take-off at Navy's Chincoteague missile center show. Also . . .



. . . Regulus now needs no chase plane but can be ground guided from these trailers.



Like its manned cousins, this versatile bird doesn't need JATO . . .



One bird slides easily from twin cacoon on submarine's deck while second missile waits for it to clear before rolling down and around to the ready.



. . . to take off on its mission from any of the Navy's aircraft carriers but . . .



. . . uses conventional steam catapulting gear plus inexpensive disposable dolly . . .



. . . that splashes off carrier's bow as airborne Regulus streaks off to target.

to be operational, this improvement is supersonic and has greater range. It will require only slight modification to fit current *Regulus I* (submarine equipment and like its older brother, its got wheels for training and testing.

The secret of success of the *Regulus* program makes very interesting reading. Being a relatively simple conception in its original form, more time was available in the beginning to develop an operational missile system. Less had to be spent chasing down some of the more exotic bugs that infest our hypersonic and ballistic efforts. Once the system itself was perfected, improvements came naturally.

In all its life, *Regulus* has flown fewer than 300 hours, but they were hours well spent. For if something went wrong with a flight, in most cases is was possible to direct the missile back to base for a wheels-down landing. Then the recalcitrant circuit, the twisted mechanical linkage or the overheated tube could be chased down and studied in detail. How many Northrop and Air Force engineers would rather have a whole bird in the hand than a twisted wreck in the Brazilian bush?

Not only did this advantage of being able to recover the missile intact enable early perfection, but it also expedited improvements for the same reason. What's more, of course, it saved the American taxpayer a lot of hard-earned dollars.

The Navy figures that even if the current *Regulus* amounts to little more than a highly successful unmanned Kamakazi, it has gained a good sound reliable missile system on which it can build effective future generations. For after the *Regulus II* will come the *Triton*—a "zip" fueled, ramjet powered bird with a 1500 mile range at speeds approaching Mach 4.0, a natural outgrowth of 100 per cent complete *Regulus* knowhow ✶



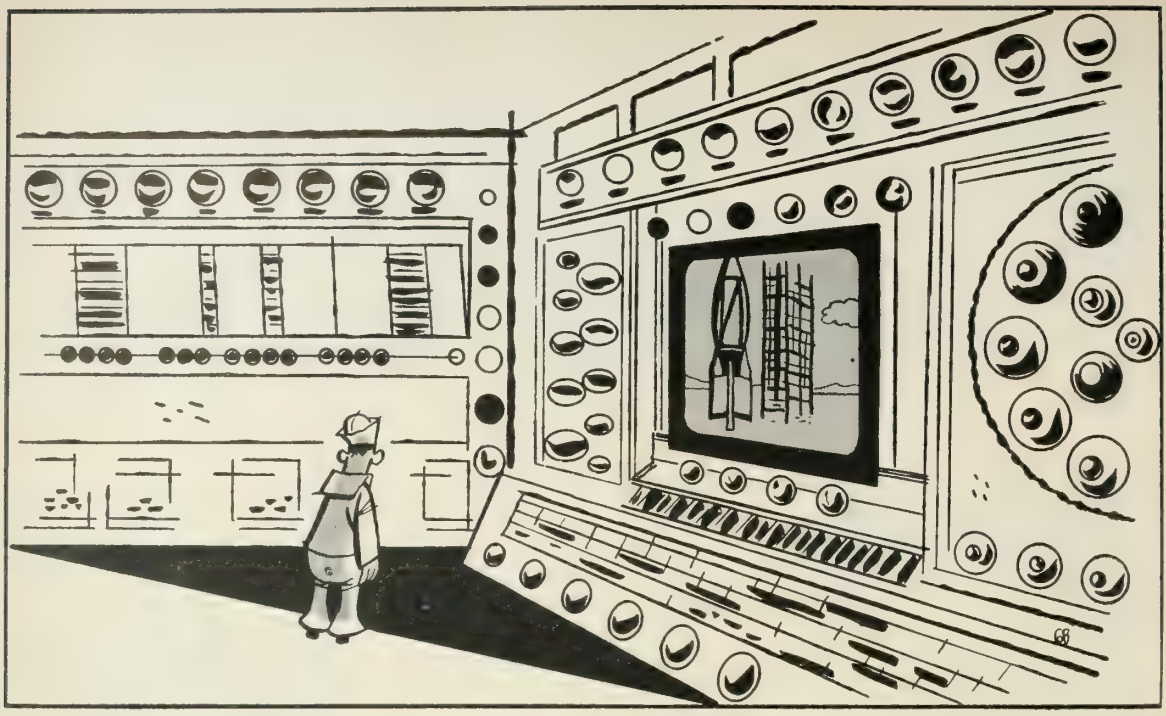
Cacoon door closed, Regulus is quickly mounted, elevated and ready to fire . . .



. . . and as JATO smoke and fire obscures conning tower, the Navy's pride . . .



. . . is airborne, the submarine having been on the surface for only a few minutes.



Too Many Pushbuttons

By Donald E. Mullen
Missile and Ordnance Systems Department,
General Electric Company

THE NAVY CHIEF entered the block house at the White Sands Proving Ground, New Mexico, to witness his first guided missile firing. Four hours and two aborted launching attempts later, he summarized his views —"I know why you can't make it work; too many pushbuttons!"

It was an obvious remark to make, but its true implication is of vital importance to the nation's defensive strength. In fact, the remark can be used as a very serviceable definition of the greatest remaining problem in the development of practical missile weapons—usability. Unless these complex weapons are simplified and made reliable, our arsenal will be stocked with impressive but useless machinery, totally beyond the comprehension of our men in the service.

To this end, industry and all the procuring services are placing top priorities on reliability, simplicity, safety and similar practical characteristics for guided missiles. While there is no pat answer to the problem of achieving reliability and simplicity in guided missiles, there are giant steps in philosophy that approach this goal.

Before defining these steps, the goal must be defined in meaningful terms. For instance, if a Task Force Commander is about to launch a close support missile over his own ships, how safe should he insist that it be? If he demanded that no more than one missile in 5000 would fail disastrously, this would not be unreasonable. Translate that kind of reliability to an automobile. Taking one trip a day, we could then expect almost fourteen years of untroubled driving.

Understanding the need for this kind of reliability is simple. Achieving it in the battle area is something else again! The classical methods fall into four categories.

Redundancy is one of these, but two of everything adds weight, cost and complexity. It means that a missile soon gets uneconomical, unwieldy and beyond the ability of a sailor to cope with the maintenance and operation of its complex circuitry. In some cases, however, this is the only practical way out.

The second approach is through "fail-safe" design. Reliability, as such, is not considered to be all important here. If a component fails, it does so in a manner designed to prevent catastrophic failure of the weapon system. Again, this is not the best answer, since it could result in substantial numbers of "duds"—as safe for the enemy as for our own troops. But in many instances, it is the only answer.

The most direct, and hardest approach to reliability is to simplify: simplification holds the greatest promise for the future of truly practical missile weapon systems. The fewer the parts, the fewer potential failures, and the fewer the parts, the easier the system is to cope with. The means for the creation of reliability, simplicity will become the guide lines for all missile men. There are any number of reasons why it is extremely difficult to simplify, but it is an old saying that the most worthy accomplishments entail the hardest work.

First problems of simplification are the limitations in the "state of the art."

In essence, this means that no one knows how to do it and/or no one has ever done it before. Assume, for example, that the problem at hand is to design an extremely accurate guidance system for the intercontinental missile. The first demonstration of feasibility in the laboratory might be the wildest dream of the scientist. He cannot and must not be bothered by the fact that his first breadboard circuit in the laboratory may not be simple or reliable. And no manager in his right mind would attempt to force such considerations on a truly creative mind. Developing increased simplicity and reliability in such a device is, in fact, another break-through in the state of the art.

Industry's answer here is to apply the ingredients of time, money and specialized talent to the simplification problem. The talent in this case, however, cannot be of the same type as the creative scientist. The simplification engineer must be dedicated to the reworking of others' creations so that the design will be compatible with the conditions of their ultimate use. Right now, these men are a rather rare breed, somewhat like operations research men and hypersonic aerophysicists. But as the need increases, the breed increases, yielding to the old law of supply and demand. It has been General Electric's experience that when we can't find them we have to make them.

The military service too has an obligation in the solution of this problem. It must conscientiously and regularly reappraise the military characteristics of each weapon in the light of the developer's progress and other new facts that have become known. It is also important that the Services differentiate between what would be nice to have and what they must have.

A typical example here might be the classic conflict of accuracy versus simplicity. The Army, for instance, has specified that a certain guided missile must be just so accurate. Should the nuclear efficiency of the warhead later be improved to yield a greater destructive force, it may mean that a relaxation of the missile accuracy requirement is possible.

Simplified Assembly and Testing

Achieving simplicity in the original design is obviously the brute force method. Because it is a direct approach, it will undoubtedly be the most fruitful over the years. In the meantime, there are other constructive methods which can be employed to ease the problem.

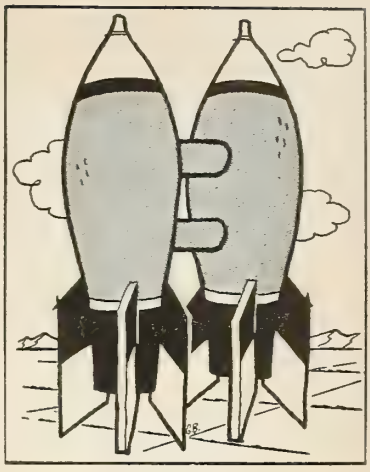
One such approach to the problem of simplicity is the *employment of advanced packaging and modular techniques*. In missiles, the added cost of this kind of assembly is not prohibitive. The initial design and manufacturing cost of any given part of a guided missile is completely lost in the cost of transporting, storing, maintaining and firing the weapon in the battle field. Further, the cost of the missile's atomic warhead is tremendous.

Add to these the true cost of a failure of a guided missile at a critical time in a battle, and it is quite apparent that it is truly economical to employ the most advanced and expensive modular techniques possible in the design of current missile weapons.

Very closely allied to the employment of advanced packaging techniques is the development of proper field test and maintenance equipment. The need, as always, is obvious, like the case of such important field equipment as a beer can opener at a picnic. In many ways, it is possible to substitute calibrated equipment for calibrated men. In military terms, this means that the average GI or sailor with the proper equipment can do the job of checking out a guided missile and then specifying the required maintenance.

All attempts to indoctrinate military personnel in the complexities of development-type testing procedures ended in abject failure. Weapons that were supposed to be in "hit and run" warfare suddenly required days instead of hours to set up, and still did not demonstrate a shred of the reliability that was originally required of them.

Getting the scientist responsible for missile development to stand still long enough to consider the testing problem is the toughest part of this approach. Second hardest is the convincing of the procuring service that high and early expenditures together with minor delays in the missile program are truly necessary to surround the field equipment problem. But in each instance of proper attention to test equipment, the post mortem analysis more than justifies the effort.

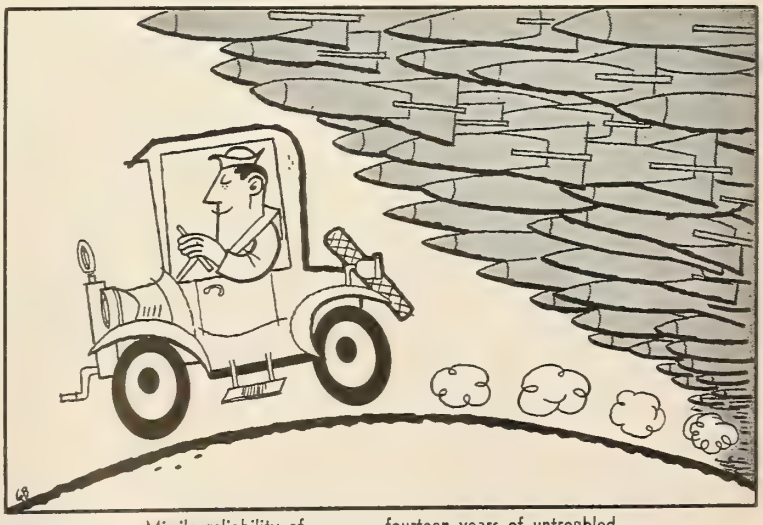


Redundancy...

When the latest in packaging techniques is coupled with truly tactical field test equipment, the problem of detecting and correcting malfunction in even the most complex equipment becomes a matter of observing either a red or a green light, followed by the replacement of a modular unit.

This utopian condition, however, is not particularly easy to achieve. First, a test method must be devised which is valid, sufficiently accurate, and repeatable. Further, the test equipment must be designed to standards similar to or even more exacting than those imposed on the guided missile. Lastly the tester shall be simple, reliable, easy to operate, and self-calibrating.

There can be no such things as



Missile reliability of 4999 out of 5000 = fourteen years of untroubled driving in the family car.



Fail-safe design . . .

testers to test the tester. It is significant, however, that tremendous advances have been made in the art of testing. Entire missile systems can now be tested remotely and automatically throughout a simulated flight procedure. The resultant go or no-go indication is then sufficient information for the operator to press the firing button or to call the maintenance man. Since the feasibility of this type of testing equipment has been demonstrated, it now remains for the military services to insist on test equipment considerations from their contractors from the outset of research and development on a missile weapon.

"Horse Sense" Helps Too

In all the approaches thus far, the answer has appeared to be the result of time, money and manpower. There is another which required none of these.

Early in one missile program, for example, engineers were confronted with the need for a positive and reliable device to indicate that combustion had occurred in the rocket motor. The laboratory was soon filled with breadboards using thermocouples, pressure sensors and photo electric devices in various complex circuits.

One man looked at the problem a little differently. He advised the use of a piece of wood with a bare wire stapled to it. If this assembly were placed at the exit of the rocket motor, he was sure it would disintegrate when the motor was burning properly.

This device, called the "burp board," is now several years old and still in use. It represents the type of analysis that results in the simplest possible method to perform the required function. This is the type of thinking which can produce more practical weapons immediately. Like all the other solutions, however, it does have its drawbacks.

Engineers can be directed to be ingenious, but it's rather difficult to enforce this directive. As one engineer said when asked to use horse sense—"I didn't take that course at college."

Possibly the only other important simplification area remaining is best illustrated by the case of the old farmer who refused to buy a book on the scientific farming method because he "already knew twice as much about scientific farming as his actual procedures reflected." In other words, a lot can be gained just by making better use of current knowhow.

After the system has been designed, considering redundancy, fail-safe design, and simplification, there is yet another step to take—reevaluation. First, see that the system is properly balanced. No component should be unduly strong or weak. In the past, complex equipment has suffered from this ailment of unbalance. In World War II radar sets, for example, less than ten per cent of the components caused more than half of the failures.

The problem of balance also shows up in priorities or favors granted to engineers working on different parts of the missile. A structures man decides he needs an additional bulkhead for strength. It passes through an area previously reserved for the electronic guidance. The proper answer to the question, "Who gives?", must necessarily be the subject of a study in system balance.

Also a part of evaluation is the second look at the validity of the developed system as an answer to the military problem. Questions of weight, size and pay load can be satisfied by inspection. Where the reevaluation becomes complex is in the area of strength of materials and the true nature of the stresses caused by the environment all the way from the factory to the target. No matter how diligently a design has been pursued, if we don't know what it must withstand, we don't know that it will survive.

Seven Points of Reliability

Using all these suggestions, a very worthwhile approach to the development of a guided missile weapon can be synthesized:

1—Military specifications—the system performance requirements—must be written so as to provide the maximum possibility of ending up with a truly practical weapon;

2—Specifications must be reevaluated and changed continuously, taking care that such changes will not destroy the continuity and effectiveness of the development program.

3—Industry must plan and man its projects so that proper attention is given to designing for simplicity.

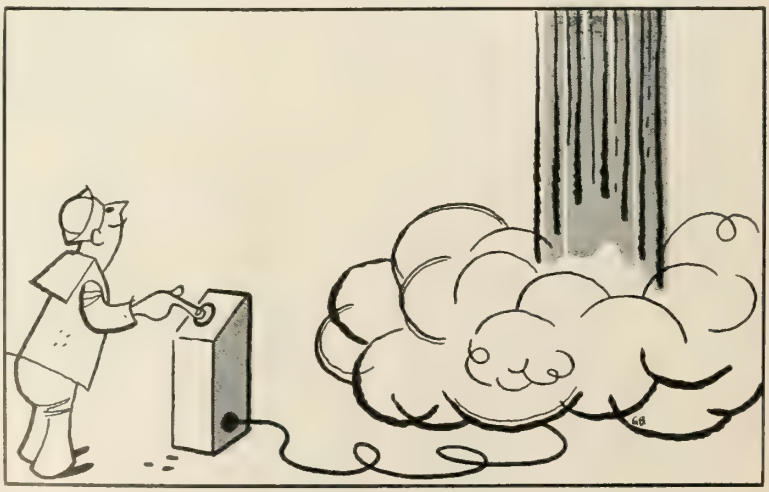
4—Principles of redundancy and fail-safe design must be included when necessary to assure appropriate reliability and safety.

5—Advanced packaging techniques, including modular design should be coupled with the latest in field test equipment to assure maintainability and constant weapon readiness.

6—True functional analysis should be applied to assure that the simplest possible method for performing the given function will be employed.

7—And in all the above things, both industry and the military should use their utmost capabilities in the creation of a practical missile.

If all these things are done, the guided missile system of the future will be worthy of all efforts and the dependence placed on it as the backbone of this nation's arsenal ★



Simplification . . .

Simulators in Navy Missile Training

By LCDR John Huson, USNR, and Chief Keith K. Smell, TDC, USN

BECAUSE OF the lethal qualities of guided missiles they should and can be entrusted only to the care of highly skilled military personnel. Reasons for this high degree of skill and the means for obtaining it involve complex scientific and educational problems.

The rapidity with which the military research and development program is moving, particularly in guided missiles, demands new and more effective methods of training men in highly complex skills. In the beginning, technical military training followed the pattern of the guild system. Ships were built by craftsmen assisted by apprentices and laborers. Design of equipment was headed by the oldest member of a shipwright house and carried out by lesser members of the companies.

Use of equipment was taught by on-the-job methods; this was effective but slow and sometimes quite dangerous. Special groups would be trained and these men in turn would train other individuals. Even the most simple equipment was painstakingly taught in order to insure proper use.

No great strides were made in the field of military training until a dual crisis arose in World War II. The problem of training men in an incredibly short time with scarce and expensive operational equipment required immediate solving. A more subtle problem arose from the fact that research efforts were creating new knowledges and weapons faster than men could be trained to use them effectively. Steps had to be taken which would train men in larger numbers, faster, safer, and at a lower cost.

Today, much the same is true in the missile field. The dynamic progress of research and development necessitates accelerated training programs for military personnel who must operate and maintain the new equipment.

Yet the sources for obtaining necessary information are too widespread and diversified; there are no missile engineers graduating from colleges; and the weapon system team concept has not yet been fully enough developed.

In spite of these difficulties, men must be trained more thoroughly in a wider variety of skills than at any previous time in our military history. In the first place, the guided missile is a complex piece of equipment with equally complex testing and computer equipments. All of these must be maintained and operated intelligently within sharply defined time and accuracy limits. The margin for error is further reduced because once launched, the guided missile cannot be retrieved. It is too costly to permit trial and error launchings.

The variety and complexity of skills to be learned by guided missile personnel within pressing time limits, present a formidable training problem. But it can be substantially reduced by the use of properly designed and properly utilized training devices.

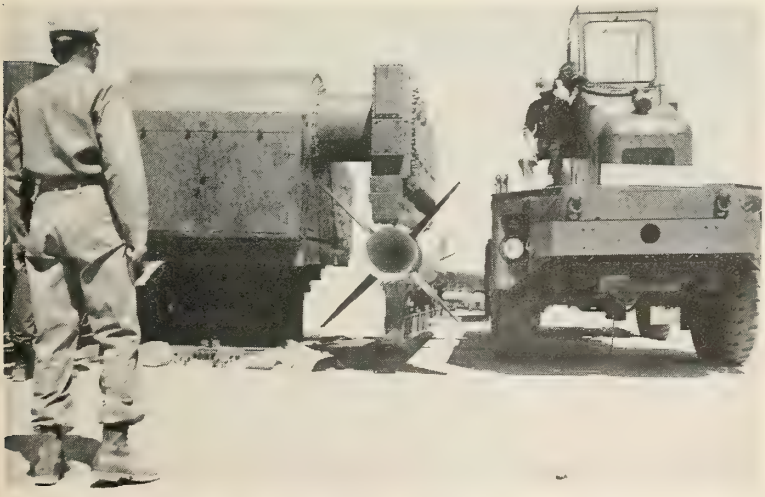
Such devices have proven their worth in many fields of military training. The use of a bomber flight trainer, for example, has been credited with saving the U.S. Air Force 119 lives and $28,850,000 in a period of one year. The Navy estimates the cost of training men in operational aircraft to be $560 per hour, as against $66 for equivalent training in a flight simulator which never leaves the ground.

The time required for training with simulators and other synthetic equipment is shortened because they can be operated day and night without regard for weather or other conditions which would affect the availability of the operational equipment. Synthetic training devices have been and are being developed for all the armed forces and for all aspects of modern warfare, whether it is airborne, surface, or sub-surface in nature. Over $135,000,000 worth of training devices are now used by the services.

In the guided missile field training devices have the following advantages:

1—Saving lives in hazardous situations.

2—Saving operational equipment for tactical use.



Navy's Training Device Center missile simulator package includes a complete store of spare parts for replacement when trainees make a mistake. Shown is the Marine Corp's mobile TERRIER launcher.

3—Increasing the number of students that can be trained.

4—Permitting accurate scoring of the student.

5—Enabling training to be stopped at any point for instructor guidance.

6—Enabling training to be carried on independent of weather conditions or availability of operational equipment.

7—Enabling round-the-clock 24 hour training to be conducted.

8—Lowering the cost of training.

9—Training men in less time.

10—Permitting standardization and improved team or crew training.

11—Sustaining the proficiency of personnel.

The U.S. Naval Training Device Center (Port Washington, Long Island, New York), under whose technical direction industry has provided more than 30,000 training devices to the military forces, has developed trainers specifically for the guided missile field. Particular effort has been directed toward designing low-cost trainers to reduce the effect of obsolescence resulting from the rapid progress and changes in missiles.

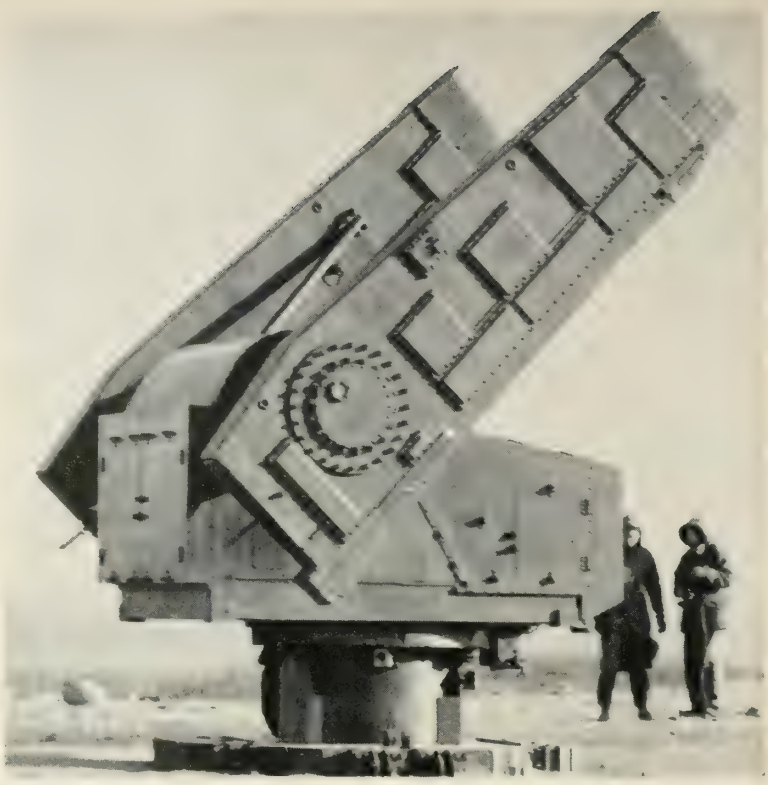
The development of adequate guided missile training devices involves many complex steps in analyzing the details of the training requirements. The type of training device is based on the multiple considerations of a set of variables such as environment, instructor qualification, student level of skill, level of skill to be attained, length of course, curriculum in use, subject material and hours of training.

In weighing these factors, the possible solutions are further subjected to close scrutiny to determine complexity, cost, lead time and useful life in the training program. Finally the most suitable synthetic training equipment is specified. The Naval Training Device Center follows this pattern of operation in the missile training equipment programs it has underway for the Army and Navy.

Industry, too, plays an important part in the development and production of guided missile training devices —by designing, developing, and manufacturing such devices under contract to NTDC.

At first it was necessary to train private enterprise in this new and specialized field. As a consequence many early devices were delayed while a contractor was being educated in the unusual training or simulation techniques involved. Industry needs information and equipment pertinent to the projects it is developing. This problem is caused by a general industrial reluctance to disseminate information and by the necessary security classication which impede the flow of information from one contractor to another.

It would be a great help if missile manufacturers would point out early in the game peculiarities of their missiles that might present serious problems in use, and therefore in training. Advance knowledge of this nature would enable training devices to be properly designed from the start. The dissemination of advanced missile design is of great importance in modifying current training device projects. Prompt relaying of technical information helps place devices in the service schools, the field, and the fleet at a time when they can be most effectively used.



Design of missile simulators calls for a lot more ingenuity than, say, did World War II Link trainers. The simulator for this TERRIER launcher, manufactured by W. L. Maxson Corp., is a full scale working mock-up, designed to fail like the real thing under mistreatment.

The weapon system analysis method for resolving the complex problems inherent in a new missile design has not been in operation long enough to determine its value as compared with other possible approaches.

However, there are additional considerations which should be included when the weapon system analysis is made. Technical consideration should be given *at that time* to development of the necessary supporting training devices.

A brief study of this problem indicates that the cost of training devices is very nearly directly proportional to the cost of operating equipment. Current figures range from 7 per cent to 12 per cent, the higher percentage being due in part to the fact that the training requirement was not recognized early enough, thereby resulting in a "crash program" which increased the cost of the training devices involved.

The ultimate goal of any military training device is to insure operational readiness. The devices developed to assist in the training of men cannot by themselves achieve this goal. They must be intelligently used by competent instructors in an environment for which they were specifically designed.

The success of our military men in the field has earned the admiration and respect of all nations. Prospective enemies are cautious in estimating the strength of the United States, a caution born of experience in operating with or against our land, sea, and air forces. This mark of prestige and efficiency has been largely made possible with the assistance of employing new methods and utilizing new training devices in training at all levels and skills.

The race between nations for technological and production supremacy in the guided missile field has been continuing for several years. It may well be that if the final count down is ever given, the superior training of men will become the determining factor. In fact, this marked superiority, made possible by diligent utilization of properly designed training devices, may be our best guarantee for a lasting peace ★

The Defense that Research Built

Working closely with various government agencies and aviation companies*, The M. W. Kellogg Company has participated in many important research and development phases of the rocket program. This has covered a wide range of missiles and rocket propulsion systems for Terrier, Talos, Snark, Sparrow, and Nike. Kellogg has also produced booster rocket cases and other components.

M. W. Kellogg's long rocket experience, supplemented by this organization's 50-year background of engineering and fabricating high temperature-high pressure industrial products, continues to provide valuable assistance to National Defense.



Including the Navy, Army, Air Force, Allegany Ballistics Laboratory, The Johns Hopkins University Applied Physics Laboratory, and such well-known aviation names as Bell, Boeing, Convair, Douglas, Grumman, Lockheed, McDonnell, Northrop, Republic.



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New Fuel Flow Test Equipment

By A. S. Kevorkian, Industrial Engineer
Rocketdyne Division, North American Aviation, Inc.

With the advent of large, liquid-propellant rocket engines such as those now being designed, developed and produced by Rocketdyne Division, North American Aviation, Inc., it has become necessary to develop whole new testing techniques.

The operation of a large, liquid-propellant rocket engine is essentially a precisely controlled, continuous explosion. Fuel is burned as rapidly as possible producing tremendous quantities of high-temperature gases which flow at supersonic velocities through an exhaust nozzle to produce the high thrusts needed to power today's missiles. In order to assure the proper function of these rocket engines, absolute control of the fuel flow rates must be maintained at all times. Testing components in rocket engines responsible for the control of these fuel flow rates such as valves, fuel lines, pumps, and thrusts chambers themselves, has resulted in the development of a unique testing device, the High Flow Bench.

Rocketdyne, which is now designing, developing, manufacturing and testing large rocket engines for the Army's Redstone missile, NAA's Navaho and the Air Force's Ballistic Missile Program, has also designed the Free World's largest High Flow Bench in operation.

This high flow test unit was built to obtain hydraulic data from rocket engine components. This data consists of accurate flow rates from approximately 100 to several thousand gallons per minute and pressures for various flow conditions ranging up to 1500 pounds per square inch.

The test medium used is clean water which is circulated through the components by large multi-stage centrifugal pumps. Since water and rocket engine fuel are practically identical in flow characteristics the flow rates and other data obtained with water are easily converted to the corresponding rates of the particular fuels being used in the rocket engines by simply correcting for the specific gravity.

The multi-stage centrifugal pumps are arranged so that the discharge can be piped into a main header with the pumps operating either in a series or in parallel. This enables the personnel testing the rocket engine components to set up the tests to be made with either maximum flow at a given discharge pressure, or maximum pressure at a given discharge flow. The flow rates are further regulated by remotely controlled throttle valves. By means of a bleed-of line or bypass line, any combination of flow rates and discharge pressures within given limits desired for the test, can be obtained. This system, designed and built by Rocketdyne, is a closed or completed circuit, enabling the clean water, after being pumped through the component being tested, to return to a water reservoir, ready for immediate reuse.

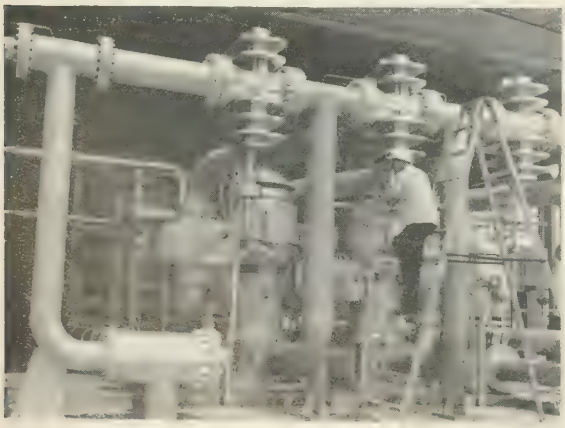
To further measure and control flow rates, a six thousand gallon water tank mounted on a scale system, as a part of the high flow unit, is used. Accurate flow rates are determined by means of time span versus pounds of water flow. Water is pumped into the scale tank and accurately measured to the nearest pound. Knowing accurately the amount of water being pumped through rocket engine component, and the length of time it takes to pump the water through the unit being tested, the recording and indicating instruments provide the actual flow data required for the test.

In order to accumulate the necessary data an elaborate system had to be designed and developed by Rocketdyne engineers for this high flow unit. The signals which are recorded or indicated are picked up by means of various instrumentation devices. Reluctance type transducers are used for pressure sensing and resistance type thermometers are used for temperature recordings which provide the necessary electrical signals for recording instruments.

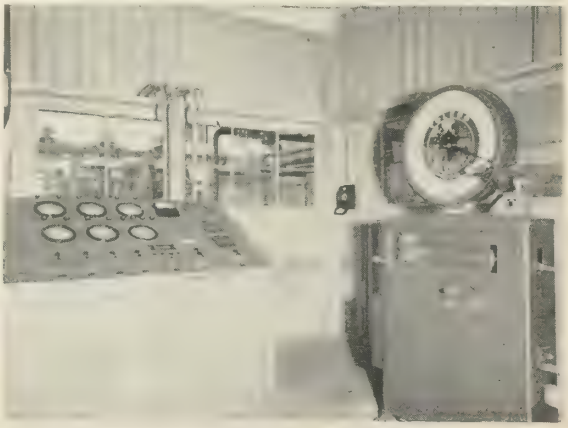
The flow rates are basically measured with the use of orifice plates, venturi tubes and turbine type flowmeters which produce a differential pressure that varies directly with the flow being measured.

This high flow bench, unique in the rocket engine industry, enables Rocketdyne to thoroughly test every rocket engine component used to handle fuel flow rates in perfect safety before the engine is assembled. Because the clean water is used over and over again, testing costs for these components can be kept relatively low without sacrificing the quality or the dependability of the engine.

Rocketdyne personnel operating this high flow bench can handle more than 30,000 gallons of water at a time



Main pipe lines from the three large multi-stage centrifugal pumps used on Rocketdyne's high flow rocket engine component testing unit. Mechanic Harold Hupp sets one of the tremendous valves on this piece of equipment, the largest of its kind in the free world.



Flow rates can be checked accurately by large scale at right. High flow bench operations are controled from console at left. Both units are a part of Rocketdyne's high flow testing unit used to check rocket engine thrust chambers at fuel control components.

and accurately measure it to the nearest quart. Any one of the three pumps used on the high flow bench is large enough to fill a large family swimming pool in the same length of time it takes to fill the average family bathtub.

Thus it is possible to obtain large amounts of accurate information on the hydraulic characteristics of a given rocket engine component from a proven rocket engine design or an experimental design at one central location at relatively low costs, and at the same time correct any malfunctioning parts before the engine is assembled and test fired.

This rocket engine testing facility is not only capable of testing components used in today's large liquid-propellant rocket engines, but is designed to handle upcoming rocket engines now under study which will be considerably larger than the ones Rocketdyne has in production today.

Gas Generators Grow

Speaking before the Chicago Section of the American Rocket Society on December 12, 1956, Mr. Alfred J. Zaehringer, President of the American Rocket Company, Wyandotte, Michigan, presented an up-to-date view of the growing use of solid propellant gas generator. Related to the rocket, the solid propellant gas generator is being used in a wide variety of military, industrial, and commercial applications. They are used on a world-wide level and represent at $10-25 million per year business. In ten years, it is expected to hit $50 million, and in 15 years will be about $100 million.

Outstanding features of the solid propellant gas generator are low cost, high reliability, low complexity, high power-to-weight ratio, ability to operate under a wide variety of environmental conditions, and ease in design. Like the rocket, the solid propellant gas generator is completely self-contained and does not depend on air or oxygen for its operation.

The American Rocket Co. has devoted considerable attention in industrial systems and has pioneered in low-cost, low-pressure, and long-burning time units. It has developed and applied a low combustion temperature propellant that can be operated safely at *any* pressure from one atmosphere on up. With low-cost and high-performance, low pressures can be obtained *directly* without a bleed-down system. Thus, extreme simplicity and high reliability have been achieved. Mr. Zaehringer said that some units had been operated from times of a fraction of a second to over an hour.

Problems and Promises of Liquid Ozone

Scientists and engineers attending the first International Ozone Conference held recently in Chicago were told "we have only scratched the surface of ozone research."

In a welcoming speech to 300 persons from all parts of the world who registered for the conference, Dr. Haldon A. Leedy, director Armour Research Foundation, deplored lack of research in the ozone field. This lack, he said, is rapidly depleting our residue of basic knowledge and is bound to reduce applied research later.

Although the conference covered, in the 65 papers delivered, many of the current techniques for producing and using low concentration ozone in the chemical industry and for municipal water purification, keenest interest was in the production and use of high concentration ozone and the determination of ozone's physical characteristics.

Use of liquid ozone as a "superoxidant" for rocket propulsion fuels would add a new order of magnitude to rocket motor thrust values possible with different fuels. However, questions on what percentage of ozone in an ozone oxygen mixture can be safely handled were refused answers. Speakers said this was "classified information."

Many researchers' reports emphasized liquid ozone's tendency to explode during laboratory experiments. Two reports, however, indicated some way to handle ozone safely may already have been found.

Dr. A. V. Grosse, The Research Institute of Temple University, revealed work being done there for the Office of Naval Research and AF's Office of Scientific Research. Despite reports of the violent instability of ozone when mixed with slight amounts of organic materials, Grosse reported success in premixing cyanogen and ozone. This was then burned to produce a temperature of 5200°K. Sometimes mixtures were left for 24 hours before burning.

Even more surprising to researchers was Grosse's prediction that "crystallization" of a cyanogen-liquid ozone mixture looks feasible. Expected temperature of combustion would be over 10,000°K, he said, and estimated pressure produced would be over "100,000 atmospheres."

Armour m/r learned, has a military contract for ozone research believed to be related to the missile field. ARF started ozone research 15 years ago, and first produced liquid ozone 10 years ago. The Foundation holds a basic patent on the hot copper catalyst method of desensitizing ozone.

It was learned also that ARF has developed a new material for liquid ozone storage containers. Portland cement is foamed to produce a "cement meringue" and is mixed with a Pearlite aggregate. Containers made this way weigh only 5 pounds per cubic foot of material volume.

The development of such containers may indicate current work in progress to apply liquid ozone to missile propulsion.

Atmospheric Ozone

Many ozone study projects are scheduled during the International Geophysical Year. Information is needed on the exact concentration of ozone in various regions of the upper atmosphere, and on production mechanics.

Dr. A. B. Brewer, Oxford University, England, said that variations in ozone concentration at high latitudes are great during the winter season. However, he said, it is not so strong at low latitudes despite the fact that ozone is supposedly produced by photochemical action of sunlight. This occurs even though there is less light in the North during the winter season. This may be related to circulation of air masses.

Study of ozone with regard to high altitude flight are under way at the Air Force School of Aviation Medicine.

Dr. Hans-Georg Clammann, physiologist at the school told of tests during which he breathed a concentration of eight parts ozone per million of air for one hour. The safety level for humans has been set at 0.1 ppm.

Clammann was subjected to the near-lethal tests last July and found his breathing capacity greatly reduced with excessive lung irritation.

Ozone has been found even at stratospheric levels. Flights beyond this point would encounter larger amounts of ozone than can be breathed safely by humans.

Evaluating Propellant Systems

By Joseph Irgon, *The Fulton-Irgon Corp.*

Determining the precise theoretical performance of a propellant system is tedious and time-consuming. It often takes several days for a hand-calculation on a relatively simple propellant, for example, one comprised only of carbon, hydrogen, oxygen and nitrogen. If lightweight metals or other high energy elements are also present, the calculation time may extend into weeks.

In the case of the more complex systems, the difficulties are compounded for two reasons.

The number of chemical species in the reaction products is appreciably increased, thus complicating determination of flame temperature equilibrium composition.

Temperature dependence of each of the many controlling chemical equilibria is far more critical at the elevated temperatures (5000°F) obtained with high energy systems.

A statistical method which provides a quick and accurate means of determining specific impulse has been developed and used with marked effectiveness by the author and his associates. Based on well-known mathematical techniques employed in the design and analysis of industrial experiments, this new approach is proving to be an invaluable aid also in the evaluation of other performance parameters.

These include such properties as characteristic exhaust velocity, hypergolicity, ignition delay, characteristic chamber length, scale factors and other propellant or engine design variables. As a generalized procedure, the method of response surfaces, as it is appropriately called, offers the most feasible means of optimizing the performance parameters under study, irrespective of their nature.

For these reasons, the various short-cut calculation methods that have been applied with moderate success to solid and liquid propellant systems in the low or even intermediate ranges of energy, have proved unreliable for determining the specific impulses of high energy systems (Isp 250 sec.). The approximate methods do not correct sufficiently for the dissociation of the product gases and for significant variations in the concentrations of the products over a small temperature range at high flame temperatures.

Machine computation methods are the most practical means of handling a large volume of propellant performance data. However, for a relatively small number of propellants the operational costs of electronic computer facilities seldom make the evaluation either economical or convenient.

The method of response surfaces provides, with the aid of sequential analysis, relatively simple quantitative models that correlate propellant or engine properties with the pertinent system variables, however complex the system. The models can be represented either geometrically or by mathematical formulae. They are readily deduced from a small fraction of the calculations or experiments required by usual evaluation methods.

Conservative estimates of savings by the new technique run upwards of 60% in the cost of development programs. This is made possible through the judicious selection of systems for study and a scientific evaluation of the data.

Examples of response surfaces in two variables are shown in the contour diagrams of Figure 1. The model is most conveniently represented mathematically, by a generalized polynomial equation that has been best-fitted to the available data by the method of least squares. It is of the form

(1) $Y=A_0+A_1X_1+A_2X_2+A_{11}X_1^2+A_{12}X_1X_2+A_{22}X_2^2+\ldots,$

where the A's are constants (multiple regression coefficients) associated with the various variables or combinations of variables X_1, X_2, X_3 . . ., and Y is the "response." Expression (1) is simply the Taylor's expansion of functions such as those representing the systems of ridges or peaks shown in the figures. The contour lines that represent constant values of the dependent variable Y, are referred to as the responses to the independent variables X_1, X_2, etc.

Illustrating the role of factor dependence, ridge systems of the type shown characterize most systems encountered in scientific and engineering work that involve two or more variables. The situation which can occur in many variables becomes progressively more complicated, as the three-variable contour diagram (Fig. 2) suggests. The latter arrangement can be regarded as being built up from two-dimensional contour diagrams.

In the absence of specialized knowledge, the method of response surfaces,

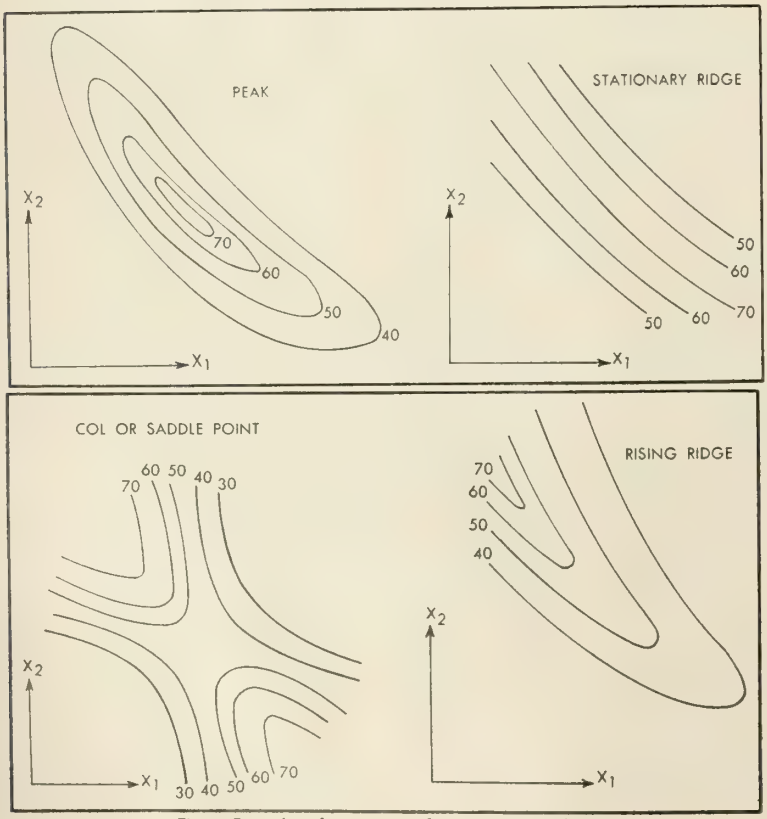


Fig. 1. Examples of response surfaces in two variables.

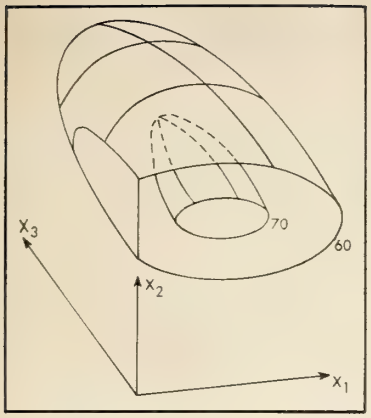


Fig. 2. A Three variable contour diagram.

which automatically takes into account the multi-factor problem, enables the optimum regions shown in the illustrations to be evaluated with considerable economy in effort and time. The conventional method would be to approach the optimum region on a hit-or-miss basis, which would require many more calculations or experiments to be performed than are actually needed.

With several factors to be varied, the possible combinations can number in the thousands. In such circumstances, it would be most difficult to determine the optimum region by the usual "one variable at a time" approach.

The investigator is apt to find himself figuratively stuck on a ridge, often without realizing it, having assumed some lower point of the ridge or peak to be the optimum. This cannot happen when employing the statistical approach, as it immediately provides the most pertinent details of the overall picture and minimizes the effort spent on unimportant features of the correlation.

Such an analysis of factor dependence in conjunction with theoretical knowledge often leads to a better understanding of the basic mechanisms governing the systems or processes under study.

It is apparent from the foregoing that the method of response surfaces is a powerful tool in analytical as well as experimental programs concerned with complex multi-factor problems and should, therefore, prove to be of increasing usefulness to the propulsion field.

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1. *Box, G. E. P., The Exploration and Exploitation of Response Surfaces, Biometrics 10, No. 1 (1954).*
2. *Box, G. E. P. and K. B. Wilson, On the Experimental Attainment of Optimum Conditions, Journal of Royal Statistical Society, Series B, 13, 1-45 (1951).*
3. *Fisher, R. A., The Design of Experiments, Oliver and Boyd, Ltd., Edinburgh, 1951.*



Propulsion Notes

By Alfred J. Zaehringer

Look to Penn Salt to introduce a new fluorine propellant. A derivative of fluorine monoxide, the compound is said to avoid the difficult handling properties of liquid fluorine. Incidentally, one midwestern university supposedly has made small scale runs on liquid F_2 combinations. Early investigations have shown that even solid fluorine reacts hypergolically with hydrogen. Present difficulties with fluorine stem from the fact that reaction with water produces ozone which then bangs off.

Organic perchlorates appear to be heading for trials as liquid monopropellants. There have been attempts to use it as a burning rate accelerator for double-base propellants. Now, a downriver Detroit chemical manufacturer is looking into electrolytic production methods.

Cal Tech scientists claim that successful runs of Diver's Solution (ammonium nitrate dissolved in liquid ammonia) have not panned out. Troubles: difficult ignition and unstable combustion. A 75% solution has a calculated performance of 175 sec, is smokeless in operation, and is extremely cheap and easy to handle and store. However, the catch seems to be operating at temperatures above the boiling point of ammonia (about—25°F) and yet above the decomposition temperature of ammonium nitrate (about 338°F). The California group believes that success hinges on finding a powerful catalyst to promote smooth reaction between these "humps."

NACA has been running ammonia in regeneratively cooled rocket motors with heat transfer rates of 2.5 BTU/sq. in./sec. They used a novel light-weight engine fabricated from hydraulically formed sheet metal.

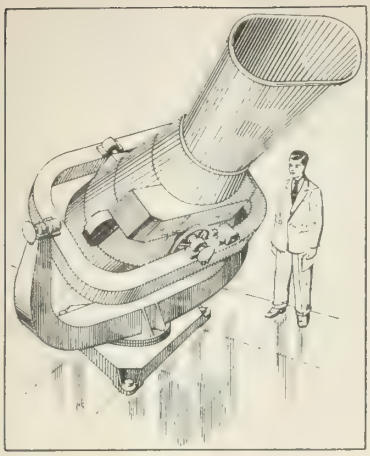
Ignition of solid propellants by detonating gases has not proved satisfactory for many combinations. Reason: low radiation intensities and absence of hot solid particles. For this reason, gunpowder continues to be a standard solid propellant igniter ingredient although the gasless or slag igniters offer promise.

Longest duration ever achieved by a large solid propellant rocket has been announced by Phillips Petroleum Co. It is claimed that a new design concept was used to accomplish this result. Operational solid propellant rockets have averaged 30 sec burning time, with lab reports of times up 5 minutes.

Phillips solid propellant materials cost is about 13¢/lb. This cost does not include materials handling and processing. Big limitation in the process is that extrusion rather than casting is used.

Honest John presumably could easily be launched from a sub today but its range (18-20 miles) will limit use to immediate coastal targets. The Soviet T-7A, also a solid propellant rocket, has only a slightly greater range (50 miles). It is assumed that our *Sergeant* solid rocket, now under development, will have a range comparable to the T-7A.

A nuclear test site is said to be in the works at the new Thiokol facility in Idaho. It is not known who will operate the facility. However it is certain that the program will pertain to nuclear rockets or the aircraft nuclear propulsion program.



Vanguard Satellite Tracking Camera Developed

By Henry P. Steier

Key to whether the artificial earth satellites will tell us anything really new about the earth itself is the ease and accuracy with which they can be tracked.

Data on ambient conditions at orbital altitude can be telemetered to earth, but getting new facts about the earth depends upon observations of the satellites made from the earth.

Using an accurate computing system, the position of the satellite as checked by observing stations is expected to give information of previously unobtainable accuracy.

Determination of station location relative to the center of the earth and to each other is expected.

Out of a research program based on the observation positions of masses on the earth's surface, shape of the earth, distribution of mass within the earth and atmospheric density should be determined with new accuracy.

Smithsonian Astrophysical Observatory (SAO) has been assigned responsibility for obtaining the observation data and processing it. Twelve or more special satellite tracking cameras will be employed in a precision optical program designed to photograph the satellites as they pass over each station.

In addition, a visual observer organization will be set up under the direction of a National Committee of Visual Observers. They will use binoculars or monoculars and an accurate time source.

The visual observations organization will be headed by Dr. J. Allen Hyne of SAO and directed by Mr. Armand Spitz. During the final stages of the satellites' lives when they are rapidly spiraling to earth, the visual tracking work is expected to be very valuable.

Exact locations of all camera stations has not been revealed. Observation points for cameras are reportedly being considered for Alexandria, Egypt, Casablanca, Morroco, Hyderabad, India, and in the Union of South Africa and Australia. Best sky transparency and freedom from clouds is important.

Camera Details

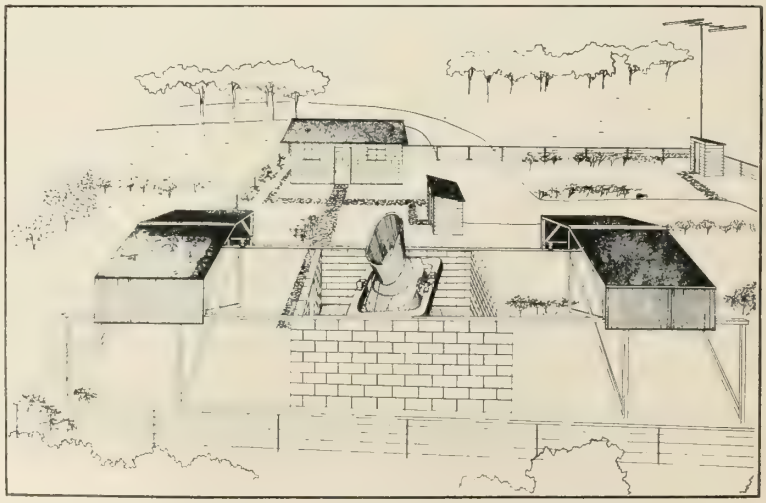
Goal of the tracking effort is to obtain positions occupied by the satellites during each orbit to within seconds of an arc and a few thousandths of a second in time.

SAO has designed a special camera to fill the need for a photographic technique that can observe a satellite with an assumed perigee of 200 miles and apogee of 1500 miles.

Optics have been designed by Dr. James G. Baker of SAO, and the instrument by Joseph Dunn and Associates, Cambridge, Mass.

The Baker-Nunn camera, as it is known, uses a photographic Schmidt system with 20 inch aperature, 31 inch Schmidt mirror and focal length of 20 inches. Performance at the edge of the camera field is said to be better by 100 times than a classical f/1 Schmidt.

First of the cameras is nearing completion at SAO in Cambridge, Mass. Its



Artist's conception of a satellite tracking-camera station. Sliding roofs would cover camera during inclement weather. Antenna would be used for communication with Vanguard Computing Center in Washington, D.C. or other camera stations and visual observer stations.

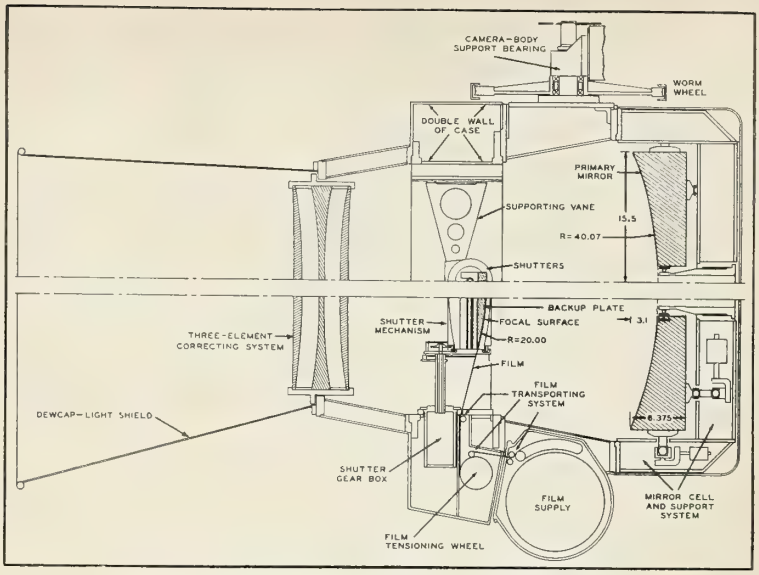
optics and film exposure mechanism was designed for taking both stills and moving pictures.

This will be done during evening and morning twilight hours when satellite visibility is at maximum. Depending upon whether bright or dark twilight conditions exist, and the satellite is far or near, different photographic techniques will be used.

A 20 inch sphere with an albedo (reflectivity) of 0.6 would have a photographic magnitude of 6.3 at 200 miles and a visual magnitude of 5.7. At 1500 miles visual magnitude would be 10.1.

Limit of vision with the eye is 5.7. Anything with a higher magnitude number would not be seen.

Angular velocity at 200 miles would be 87.8 minutes of an arc per second. At 1500 miles it would be 8.7 minutes of an arc per second. The apparent speed would be meteor-like at 200 miles and slower at 1500.



Section view of satellite-tracking camera showing film transport and shutter arrangements and Schmidt optics.

High Optical Speed Needed

The optical speed necessary to photograph the satellites under these conditions is difficult to achieve. To meet the problem of film fogging that would occur with exposures longer than 1/5 second, the camera will use continuous Kodak Tri-X film which can be transported in steps at different cyclic rates. These are determined by light conditions.

Two shutters will expose the film. A gross shutter will operate during a transport cycle and be open for 20 per cent of the cycle. In a one-second transport cycle the exposure would be 0.2 second. In the longest cycle of 5 seconds, exposure would be a full second.

During the gross shutter operating time a rotating barrel-type shutter with a period five per cent of the total transport time will interrupt the exposure for periods of 1/100 second.

This will give time marks spaced 100 microns (.0039 inch) in the satellite trail on the film. Synchronized with the rapid shutter will be a stroboscopic presentation of a crystal clock face photographed directly on the film strip. The clock accuracy will be 1/1000 second.

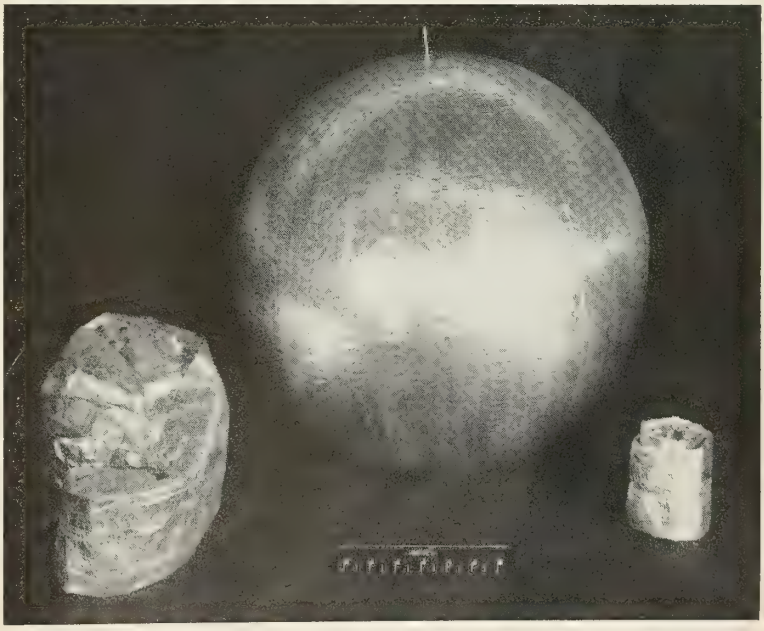
When the satellites are fainter than maximum, the fixed position will not be used. The camera will be moved in a partial motion rather than continuous.

This is because a star field will be photographed as a location reference for the satellite position. Continuous movement would show the brighter stars as long trails and faint stars would be lost altogether. The camera movement could be oscillatory or discontinuous.

The optical axis of the camera will be allowed three motions: altitude, azimuth and tilt.

An orbit calculation and prediction center located at Cambridge will act as the nerve center for communications between the Vanguard Computer Center in Washington, D.C. and between different visual and camera observation points in the world. This collection and correlation of data is one of the most important parts of the IGY Program.

Data will be rapidly analyzed as soon after the photographic work as possible. This will aid planning for later satellites which may need alterations to get the most out of them.



The new camera will be especially useful in tracking these balloon-like sub-satellites that are scheduled to be released by earth satellites. The 20-inch diameter aluminum coated plastic bags, inflated after release at altitude, contain no radio equipment and will have to be tracked visually. NACA, who developed them, expects to gain valuable upper air drag and density data by following their movements.



Plastic mock-up of an advanced design IGY satellite with scientific instrumentation. Internal bracing will support four 1/4-wave antenna dipoles as well as a central housing for plug-in modularized telemetry and Minitrack transmitter circuitry (No's 1 to 6). Ports (A and B) will expose solar cells and Lyman-Alpha instruments for orientation and ionization measurements. "C" and "D" identify instruments on the skin for measuring meteoritic erosion and temperatures.

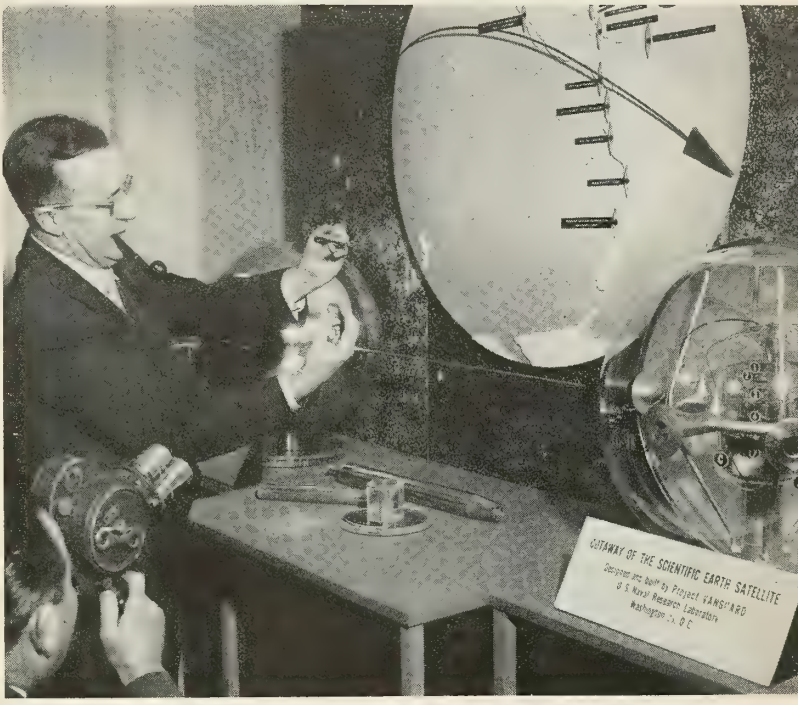
Vanguard Instrumentation

Dr. JOHN P. HAGEN, director of Project Vanguard, demonstrates with a scale model the separation sequence of the satellite and third-stage rocket motor. Behind Hagen's hands is a full-scale satellite with antennas in erected position.

Cutaway of a satellite showing internal construction is at right foreground. Geographic diagram on wall shows location of Minitrack ground radio tracking stations and direction of a typical satellite orbit. All Minitrack stations will be located in the Western Hemisphere and will provide the Vanguard Computing Center located in Washington, D.C. with data on satellite locations.

Twenty minutes after meridian passage of the satellite over a Minitrack station two bits of angular data and time of measurement will be sent to the Center.

With these data an International Business Machines Corp. 704 computer will calculate times of arrival, zenith angle, angular velocity and location of a favorable acquisition direction for optical tracking stations located in many parts of the world.



ROBERT H. BAUMANN, Group Head, Satellite Engineering Consultant Staff, Naval Research Laboratory, plugs a modularized circuit into a satellite's gold-plated aluminum astrionics container.

Astrionics for telemetry coding and transmission is designed in circular layer modules. In this way various circuits needed for a variety of scientific measurements to be made with different satellites can easily be accommodated.

This satellite prototype is being readied for pressure, vibration, and shock testing. The assembly will also be centrifuged and thermocycled to determine the satellites' fitness for forecasted conditions in outer space.





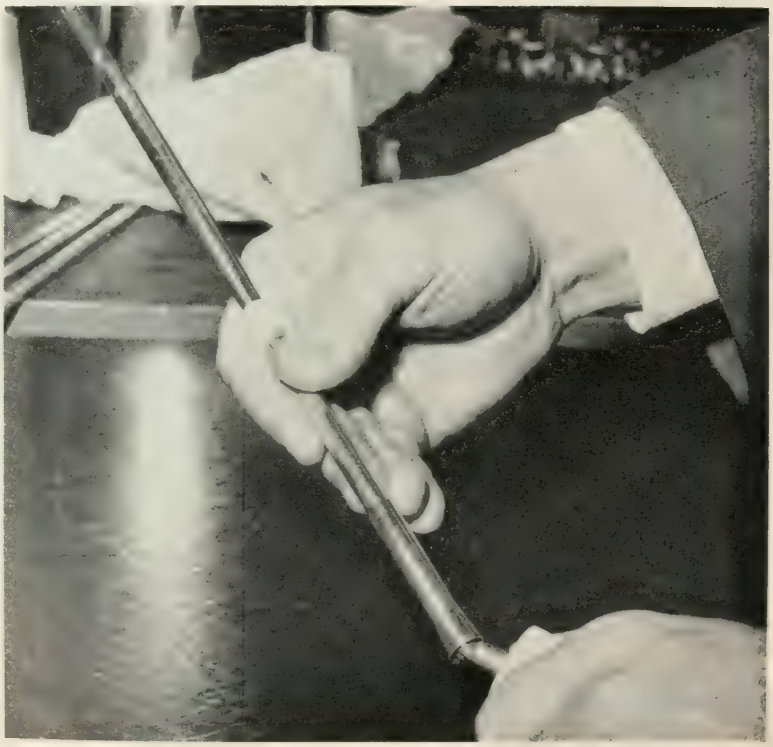
Circular printed wiring boards that go into the satellites' astrionics housing have transistors and other components fastened directly to the boards. Pin contact boards fastened directly to the circular boards aid ease of interconnecting various circuit layers.

Light colored material at top of astrionics housing is Kel-f plastic. It is a low thermal conducting material for heat isolation and support of the housing.

"T" shaped Kel-f plastic pieces will fasten to internal bracing and aid centering support of the housing.

To the right—Back through the years, Naval research has been one of the most productive scientific investigative operations at the nation's disposal. Its latest project is The VANGUARD Satellite. The diagram on the next page shows its present-day organization.

→



The four 1/4-wave dipole antennas carried by the satellite will be folded during flight of the VANGUARD vehicle to orbital altitude.

After separation of the satellite from the third stage rocket motor, the dipoles will be erected. They will be activated by a spring-loaded hinge near the base of each dipole.

After the dipoles spring into place, funnel-shaped sleeves near the hinges slip down and lock the dipoles in straight-out position.

Antennas are located around the equator of the satellite and spaced 90 degrees apart. This configuration is expected to give circular polarization needed for best radio tracking.

Satellite orientation with respect to the sun, as detected by solar cells, and ionization as measured by Lyman-Alpha instruments should add wholly new knowledge of microwave refraction indices at satellite altitudes.



Rear Adm Rawson Bennett, USN

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Astrionics



By Henry P. Steier

Anti-missile missiles will compound to new proportions the reliability and life headaches of electron tubes. *Nike* battery Commanders are already wrestling with these problems. A typical *Nike* system uses 3,500 tubes. Each plays a vital role. Operating and maintenance costs vs. readiness factors must be considered. *Nike* stations do not stay "on the air" 100 per cent of the time. Defense planning takes into account warm-up time needed for readiness.

With the anti-ICBM missile, tube life-reliability considerations will grow drastically. Radar rf generators used for *Nike* now develop power in terms of 1,000's of watts. The *Nike Hercules,* reportedly the anti-ICBM design under development for the Army, will need rf of millions of watts to seek and destroy its target. *Nike Hercules* stations would probably stay on the air around the clock since readiness time is nil. Tube engineers will soon have to face the need for the ultimate in life and reliability (as well as the extremely high power), since there will be no down-time for checking tubes.

Astrionics information was cited recently as the weakest link in the body of information available for handling ICBM offense and defense. Dr. F. J. Tischner, Ohio State University and formerly with Redstone Arsenal's electronics laboratory, said although we have radar for detection, the all important determination of exact position and velocity is very difficult. Among the weakest links are wave propagation and antenna design information.

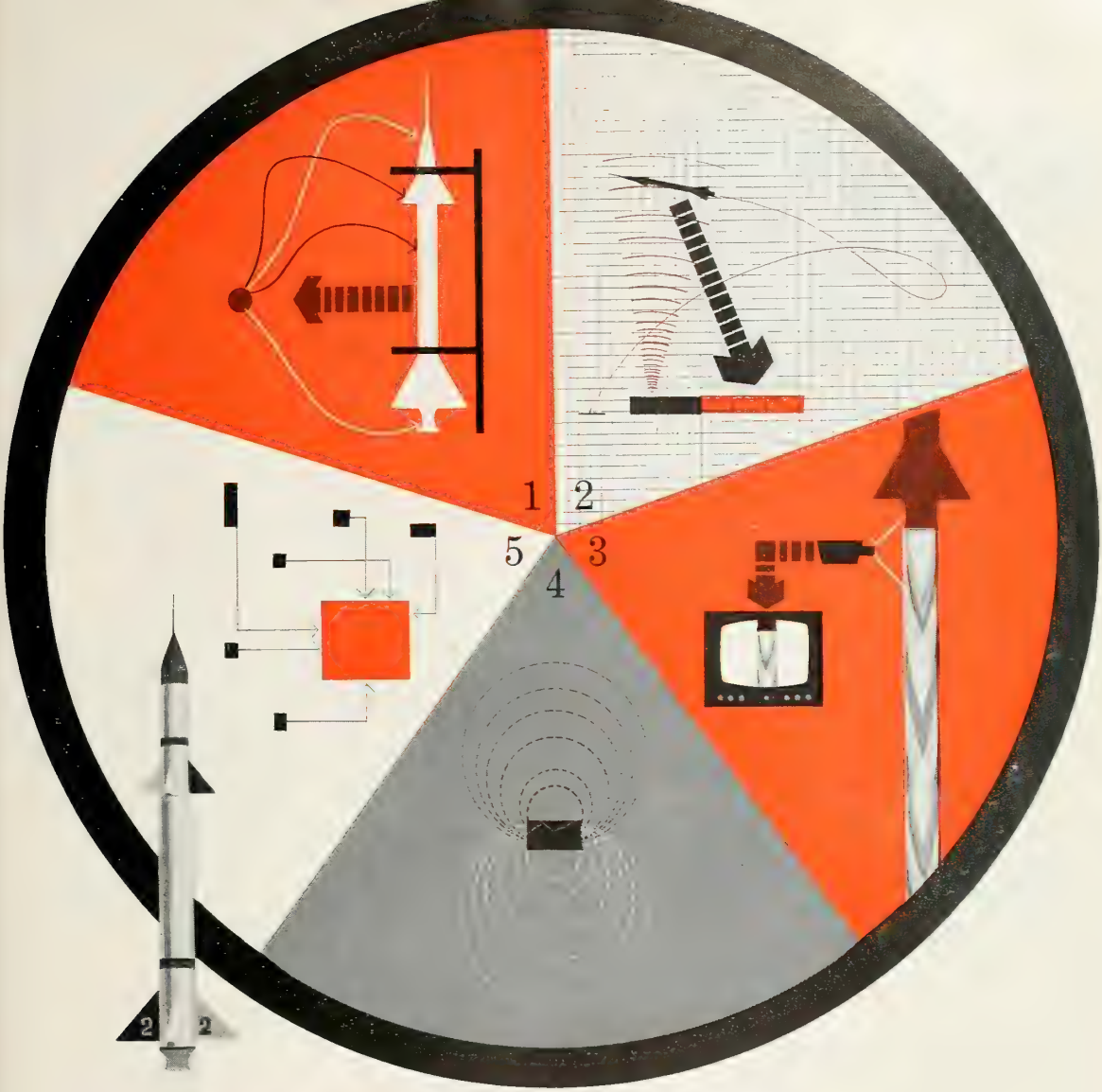
Usual approach to determination of wave propagation is through the index of refraction of the propagating medium. Microwave optics in hypersonic flight—above Mach 10—must cope with what Dr. L. M. Hartman, General Electric Co., Missile and Ordnance System Dept., calls a "monstrous lens" formed of dissociated gases in the stagnation region around the object. Electron density which regulates index of refraction begins to be considerable at Mach 10 and changes with altitude, so result would be a complex constantly changing electron lens. Besides finding a way to communicate with rockets through such a lens, the antenna would have to withstand 8,000°K.

•

One member of scientific fraternity does not think much of using solar cells for getting astrionics power from the sun. Pointing out that only about 2 kw per square yard is available, and that solar cell efficiency is quite low, he reminded his listeners that "fast growing Iowa corn uses sun energy better than semi-conductor devices."

•

Optical tracking cameras for the IGY satellites are designed but none have been completed. The first is being constructed by the Astrophysical Observatory, Smithsonian Institute, with optics supplied by the Perkin-Elmer Corp. The 12 cameras to be built will photograph satellites as they pass "with meteor-like speed" in the words of Dr. K. Heinze of the Institute. Cameras will use Schmidt optics with a 30 inch field and Kodak Tri-X film. Both satellites and reference stars near them will be photographed.



ENGINEERS & TECHNICIANS

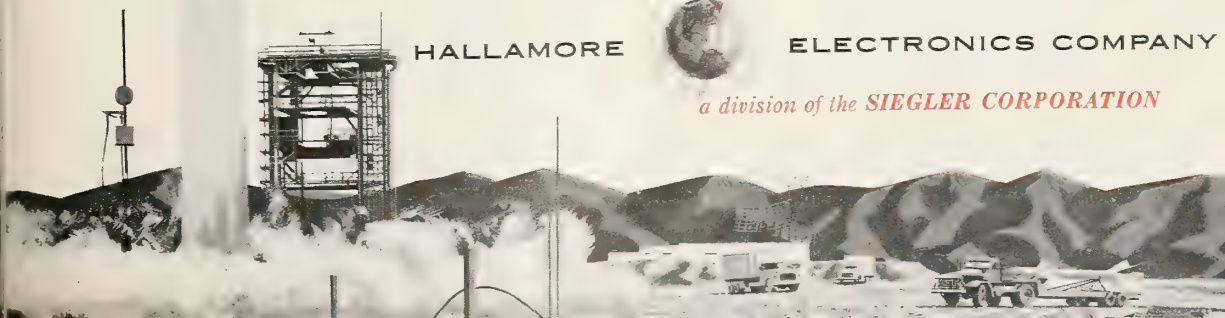
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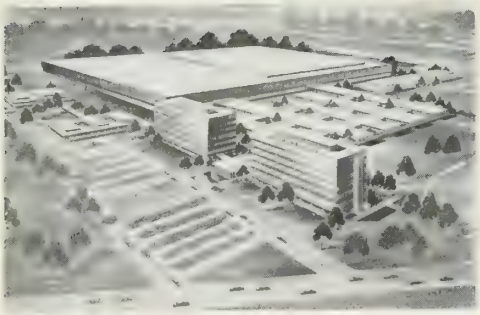
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Aerophysics



By Seabrook Hull

The optimum solution to ICBM and IRBM reentry may lie in the use of plastics rather than exotic metals. NACA hypersonic test vehicle experiments have produced encouraging results. Of the two most promising organic groups being researched, epoxy resins have relatively high melting points, particularly with curing. Fluorinated plastics, already fully oxidized by fluorine, are chemically inert under the high temperature conditions of atmospheric reentry.

Both melt relatively slowly, due mainly to the fact that the thin fluid melt layer has a very slow heat transfer rate. Certain compounds in both groups sublime with profitably high specific heats. This not only facilitates reentry design but fits the concept of manned hypersonic vehicles entailing disposable parts. Laminating materials include tempered glass and quartz. Stainless steel, nickel-cobalt or molybdenum alloy screens might be used for structural backing.

The beauty of this approach to hyperthermantic flight is its dependence on well-known industrial techniques and readily available materials. And, importantly, it's cheap.

•

Time as an absolute standard is being challenged. Ephemerous time is based on there being 31,556,925.975 seconds in the year 1900; universal time, on there being 86,400 seconds in a day. The relationship of universal to ephemerous time is a standard that has never been seriously questioned, but on which all science is based. A 5-to-10 year experiment just now beginning, however, seeks to find if time as man has defined it is so standard after all. Like the solar system—corrected for Relativity, known variations, etc.—is consistant, so is the state of the atom. Both, reduced to absolute terms, bear an unchanging relationship—or so we have assumed these many years.

Current continuing measurements of the frequency of the cesium atom at Washington's Naval Observatory may, in a few years, prove this isn't so. If it does, Relativity limitations may become potentials; man's knowledge of his infinite environment may be grossly expanded and the rate of scientific progress accelerated exponentially.

If this seems remote, remember: It was Rutherford's work in the late 19th Century and Einstein's in 1905 that ultimately lead to man-made nuclear power during World War II.

•

The practical nuclear rocket has been brought closer by a 12-man California University team under Prof. Luis W. Alvarez. Without the 100,000,000° temperatures now needed but with the same immense energy release, catalytic use of the negative mu meson "cold-fuses" heavy and light hydrogen into helium. Needed: A controllable production source of the scarce, short-lived mu meson. Outlook: Optimistic.

•

If anyone thinks ballistic missiles are "all-that-different" from military aircraft, the cost of research and development of "fool proof" guidance for long range missiles runs every bit as high as it does for the little black boxes in SAC bombers, interceptors, etc.

To the ENGINEER of high ability

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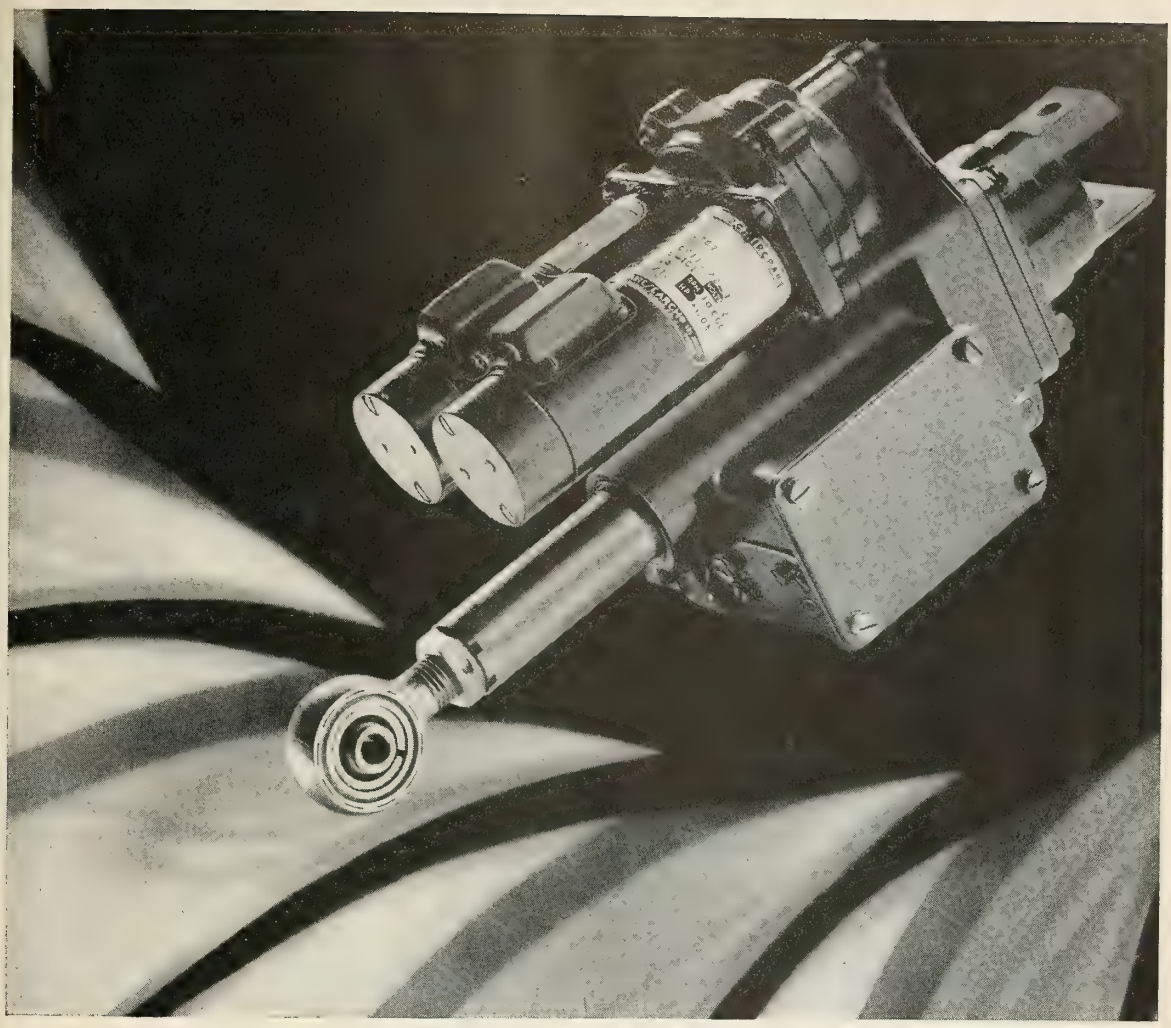
The Garrett Corporation is also applying this engineering skill to the vitally important missile system fields, and has made important advances in prime engine development and in design of turbochargers and other industrial products.

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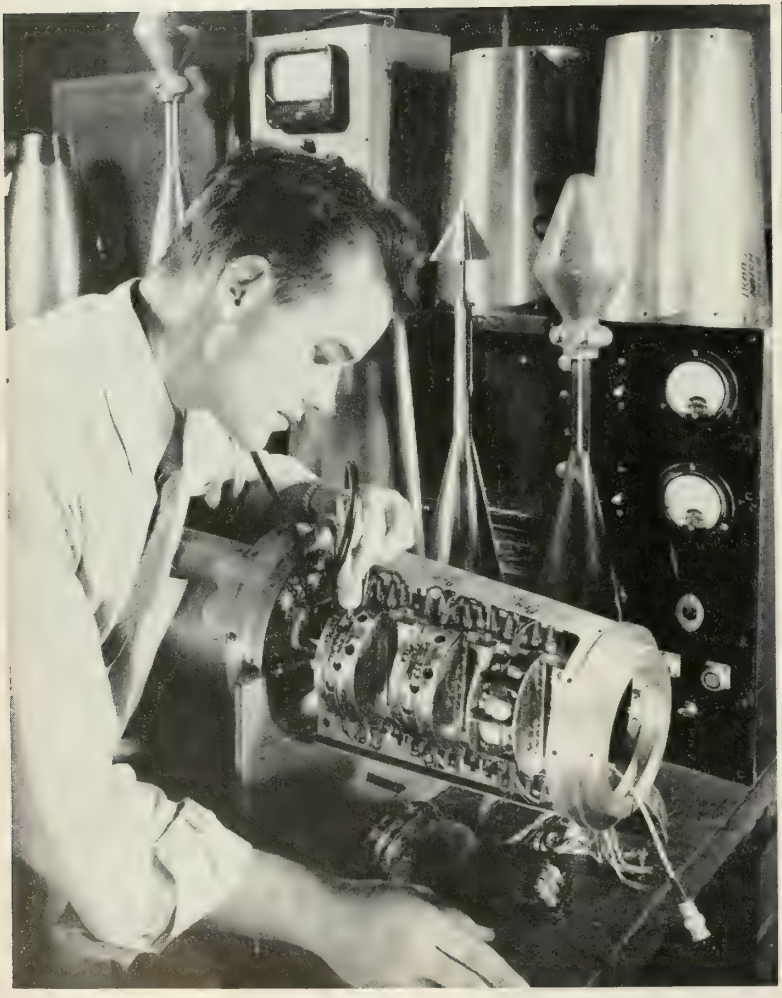
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SUBCONTRACTORS' GUIDE: Missile Electronics and Astrionics



Like a doctor checking a patient, this electronic specialist making careful adjustments to the telemetering brain of an NACA test missile symbolizes the critical importance of electronics and astrionics to the new age. In some major missile programs guidance development takes nearly two-thirds of the total project budget. The listing that starts to the right includes major U.S. companies doing missile work in the general fields of electronics and astrionics. Included are not only the names of the companies and their addresses but the names of their subcontracting officers as well. This is another *m/r* special service to its subscribers.

CALIFORNIA

Ampex Corporation
Elton Bell, Purchasing Department
934 Charter Street
Redwood City, California

Associated Missile Products Corporation
Fred Henion, Manager, Procurement
2709 North Carey
Pomona, California

Bendix Pacific Division
Bendix Aviation Corporation
Robert N. Huntoon, Purchasing Department
11600 Sherman Way
North Hollywood, California

Bill Jack Scientific Instrument Company
Richard T. Johnson, Digitac, Inc.
420 S. Beverly Drive
Beverly Hills, California

Coleman Engineering Company, Inc.
E. J. Hannaman, Purchasing Department
6040 W. Jefferson Boulevard
Los Angeles 16, California

Cubic Corporation
2841 Canon Street
San Diego 6, California

Donner Scientific Company
L. T. Anderson, Purchasing Director
2829 Seventh Street
Berkeley 7, California

Dynalysis Development Laboratory, Inc.
Kenneth R. Jackson, President
11941 Wilshire Boulevard
Los Angeles 25, California

Genisco, Incorporated
G. F. Coyle, Purchasing Agent
2233 Federal Avenue
Los Angeles 64, California

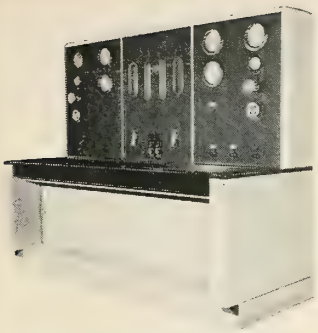
G. M. Giannini & Company, Inc.
P. A. Coleson, Purchasing Department
918 E. Green Street
Pasadena, California

Gilfillan Brothers
1815 Venice Boulevard
Los Angeles, California

Hallamore Electronics Company
(Division of Siegler Corporation)
James E. Cravens, Purchasing Department
8352 Brookhurst Avenue
Anaheim, California

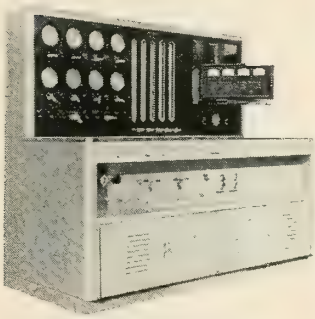
Hoffman Laboratories Incorporated
(Hoffman Electronics Corporation)
R. A. Gingrich, Purchasing Director
3761 S. Hill Street
Los Angeles 7, California

When You Count Time in Terms of λ



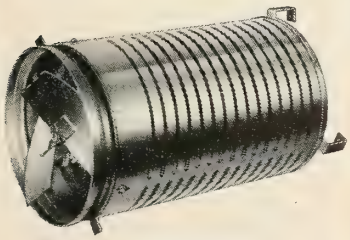
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St. Petersburg, Florida

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Miami 36, Florida

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Chicago 38, Illinois

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Planning & Procurement
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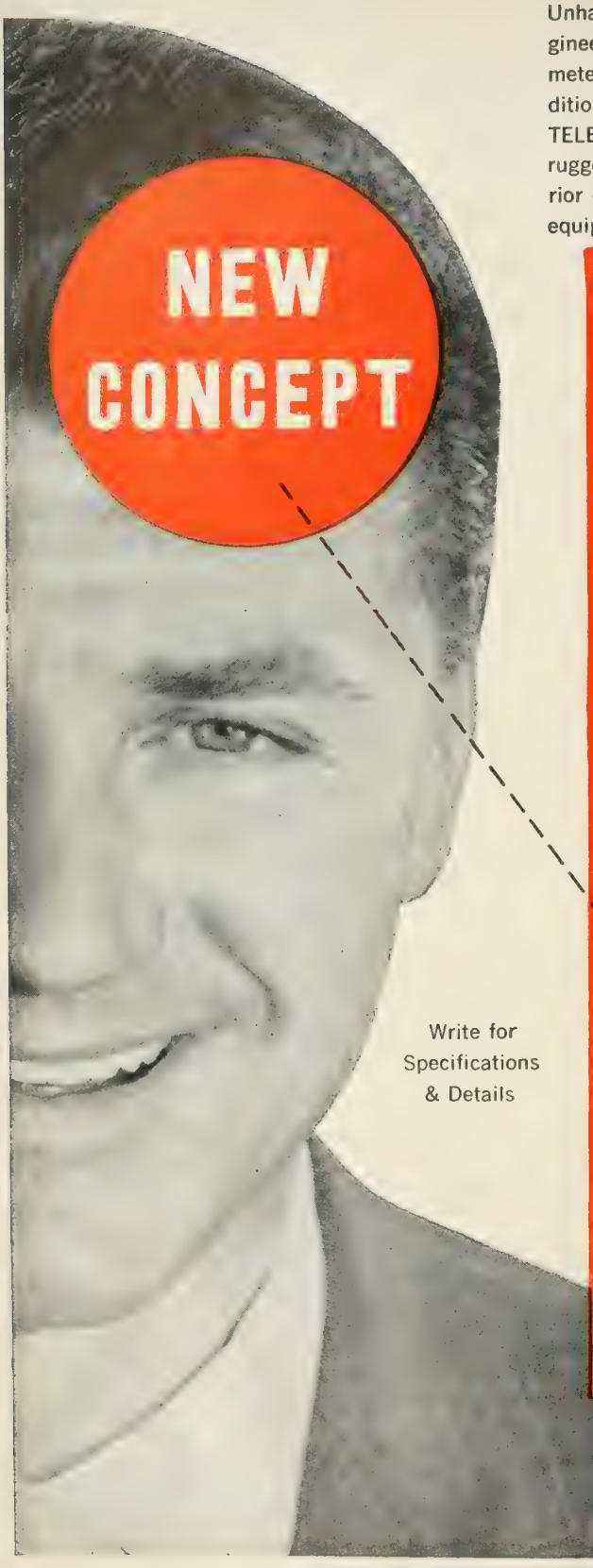
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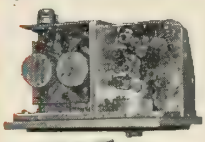
In a future issue m/r will publish a subcontractors' guide to manufacturers of launching gear & other missile components



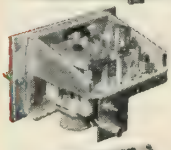
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Specifications
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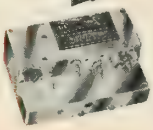
Direct FM Transmitters Crystal controlled 215-235 megacycles. 125kc deviation.



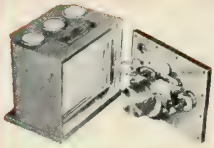
Model 1462—6″ x 4¼″ x 3¾″
50 to 80 Watts



Model 1463—5 1⁹⁄₃₂″ x
3 1³⁄₁₆″ x 4″
15 to 30 Watts



Model 1472—4″ x 1.5″
x 2.7″
2 Watts

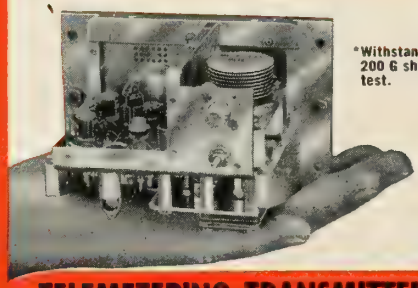


Model 1460—5″ x 4⅝″ x 3 1⁵⁄₁₆″
RF Amplifier
15 to 30 Watts



Model 800—4.5″ x 1.3″ x 1.4″

SUB-CARRIER OSCILLATOR. Deviation stability ±1% of band width. Deviation linearity less than 1% of band width under all conditions measured from a straight line drawn between end points.



*Withstands 200 G shock test.

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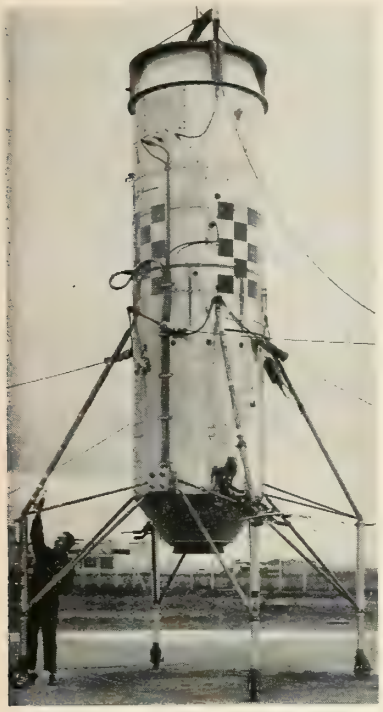
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French Coleopter Missiles Underway



Missile derivations are planned for SNECMA's "Flying Atar" VTOL test vehicle. Shown above is the original P1 version of the French device. To date it has made some 200 takeoffs and landings. A piloted version, the P2, is ready for its test program while a more refined version, the P3, with a full cockpit with a rotating seat will be the next step.

From the P3 SNECMA will build an experimental aircraft with an annular wing, the C 450. This coleopter will be subsonic. It will make vertical takeoffs and landings but will fly like a conventional aircraft. Subsequently SNECMA will build a coleopter with a ramjet as well as an afterburner-equipped Atar turbojet. The ramjet will be installed in the space between the jet engine and the annular wing.

Eventually the "Flying Atar" will be developed into a Mach 3 vehicle, either in the form of a missile or a piloted aircraft. In five to ten years SNECMA can envisage civil applications of the formula. The most important use for the coleopter type of vehicle, however, is likely to be military in view of its small size and outstanding performance.

World Astronautics



By Frederick C. Durant III

Outside of the U.S. only two countries have reported work on three-stage rocket vehicles. One of these was the Japanese *Kappa* rocket program, (m/r October 1955). The other rocket, a French one, is known as the *Monique*. The program has been under way for more than a year but little information has yet been released. Use of staged rockets introduces the designer to problems of clean separation and smooth ignition at space-equivalent conditions.

Japan's initial series of rocket tests in preparation for the IGY came to a successful conclusion in December with the launching of the seventh Kappa 128-JT at Michikawa. The test program is expected to be resumed in March when a double Kappa rocket will be launched.

•

British physicist Arthur C. Clarke is known equally well for his writings in science (EXPLORATION OF SPACE) and science-fiction (THE CITY AND THE STARS). Completing a five months' lecture tour of the U.S. he met with key individuals of Project *Vanguard* at the Naval Research Laboratory and Martin, Baltimore. In addition, he talked with those at The National Academy of Sciences and The National Science Foundation concerned with the overall U.S. program for IGY satellite vehicles. First hand impressions gained will end up in a forthcoming book on satellite vehicles to be published this fall by Harper and Brothers. The tentative title is THE MAKING OF A MOON.

•

On New Year's Day, Dr. J. Allen Hynek, Associate Director of the SAO, left for a month's tour of South America to follow up preparations for the official optical tracking program and to evaluate the interest in volunteer observing teams. First stop on his trip is Buenos Aires, where Hynek will meet with the Argentine IGY Committee Chairman and Professor T. M. Tabanera.

•

Einstein's Restricted Theory of Relativity (1905) contained one theorem entitled "The Behaviors of Measuring Rods and Clocks in Motion." Interpretation of this theorem has led to periodic controversy. The question is if a "clock" moving at near-light speeds would keep slower time than a "clock" which, relatively, is stationary. At the Seventh Congress of the International Astronautical Federation at Rome last September there was speculation on human aging rates under the same relative conditions. Kurt R. Stehling has a neat, witty summary of articles on the matter in the January issue of the ARS JET PROPULSION. Prominent scientists take contradictory stands. The ability to hurl sub-atomic particles at near-light speeds may provide data to settle this intriguing paradox once and for all—in any event, probably before any future generations have to test the time dilation effect in manned space vehicles.

•

Eighth Annual Congress of the International Astronautical Federation will be held at Barcelona, Spain, October 6-12, 1957. A focal point for technical papers and discussion on rocket and astronautical subjects, with representatives of twenty-one countries, the size of the Congresses has grown rapidly. More than 70 U.S. visitors and delegates were present at Rome. With the advent of the IGY and the anticipated *Vanguard* launchings this year, the Barcelona Congress is expected to be an outstanding event. A brochure describing the history and aims of the IAF is available upon request to: IAF, 35 Lowell Road, Concord, Mass.

European Rocket Engineers in Argentine Astronautics

By Frederick C. Durant, III

SOUTH OF THE equator the world center of astronautical interest is in Buenos Aires, Argentina. There, the Asociacion Argentina Interplanetaria (AAI) has achieved national recognition for its many diverse activities.

Right now, the AAI is busy preparing for the optical tracking of the U.S. satellites. During the Seventh Congress of the IAF held at Rome last September (M/R October 1956) Professor Fred L. Whipple, director of the optical tracking program for the U.S. satellites outlined the need for volunteer tracking teams. The AAI was one of those IAF Members interested in the problem.

Founder and energetic President of the AAI is Prof. Teofilo M. Tabanera. In 1930, as a young mechanical engineer, Tabanera wrote his first article on the possibilities of space flight. Eventually, in 1948, he organized a study group including: Ing. Felipe Reca, Sr. Francisco von Proschek, Sr. Carlos Krotsch, Sr. Juan Lazlo, Ing. Jose Ovidio Martinez, Ing. Rodolfo Martinez de Vedia, Sr. Juan Landajo, Sra. Herminia Balado, and Sr. Arturo Loeffler.



Asociacion Argentina Interplanetaria President and astronautics pioneer PROFESSOR TEOFILO M. TABANERA., well-known IAF personality.

Austrian-born von Proschek has been an electrical engineering specialist with the Buenos Aires branch of the Siemens-Halske, AG, for twenty-five years. Krotsch and Lazlo are both of Austrian descent. They are electrical engineers each with more than 20 years experience with the Siemens organization. Martinez has a mechanical and electrical engineering background and is a consultant for the petroleum industry and is president of the South American Petroleum Institute. Martinez de Vedia has been a professor of mechanical engineering at La Plata University for nearly twenty years.

Also included in AAI membership are: Dr. Otto Waltz and Ing. Ricardo V. Dyrgalla. The latter, a current AAI director, who received his science degree from the University of Danzig before the war, served as an RAF fighter pilot and later as scientific officer at the RAE, finally emigrating to Argentina in 1947. In 1948 he designed and tested the first Argentina liquid propellant rocket motor. Dr. Otto Waltz, a former German, at one time designed V-2 fuel pumps for H. Walther at Kiel. Near the end of the war he developed rockets at the Schmidding works. He is now technical advisor to the D.G.N.F.M. (General Bureau of Military Production).

The Sociedad Argentina Interplanetaria was officially established in 1951, later changing to the present title.

Growth of the AAI passed the 600 membership mark in 1956. About one-third are professional people, university graduates; one-third, technicians and specialists; and one-third, university and technical students. It is interesting that the U.S. Earth Satellite Program has had little effect upon the rate of growth. The battle for acceptance of astronautics as a legitimate science had already been won in Argentina.

German Scientists Help

Of no small help were the dozens of German scientists and engineers who emigrated to Argentina after World War II. Some of these men had played a part in World War II German rocket developments. Many are now employed by the Argentine aeronautical industry and the Institute of Scientific Research of the Armed Forces.

AAI activities during the past few years have been varied. In Argentina defense requirements rocket research are small. Interest in astronautics is, therefore, self-generated.

Papers have been presented on subjects ranging from "sounding rocket research," "electronics requirements of rockets," "interplanetary navigation" and "uses of plastics in astronautics" to "legal aspects of artificial satellites" and "space medical research." Dr. Aldo Armando Cocca, recently a delegate to the Legal Committee, ICAO meeting in Montreal, is one of the small group of lawyers who have in recent years given careful consideration to "space law."

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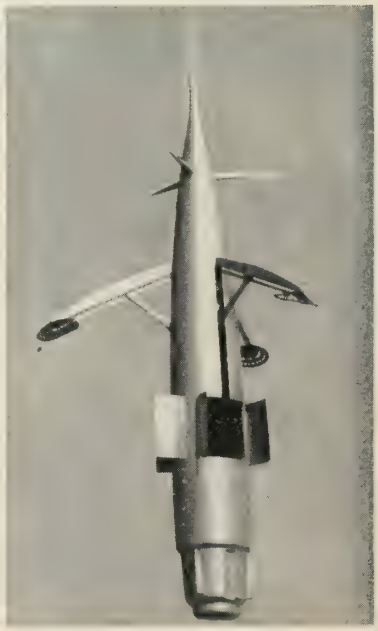
The works of Drs. H. J. A. von Beckh and Heinz von Diringshofen of the National Institute of Aeronautical Medicine in Buenos Aires have been reported in the Journal of Aviation Medicine in the U.S. Papers by Cocca, von Beckh have been presented in behalf of the AAI at the annual congresses of the International Astronautical Federation in Europe.

The AAI has conducted two six-month astronautics courses, basic and advanced, for the past two years. Under the direction of Dr. Otto Waltz and Ing. Ricardo Dyrgalla a small group of younger members of the AAI have calculated, designed and constructed a liquid propellant micro-rocket motor.

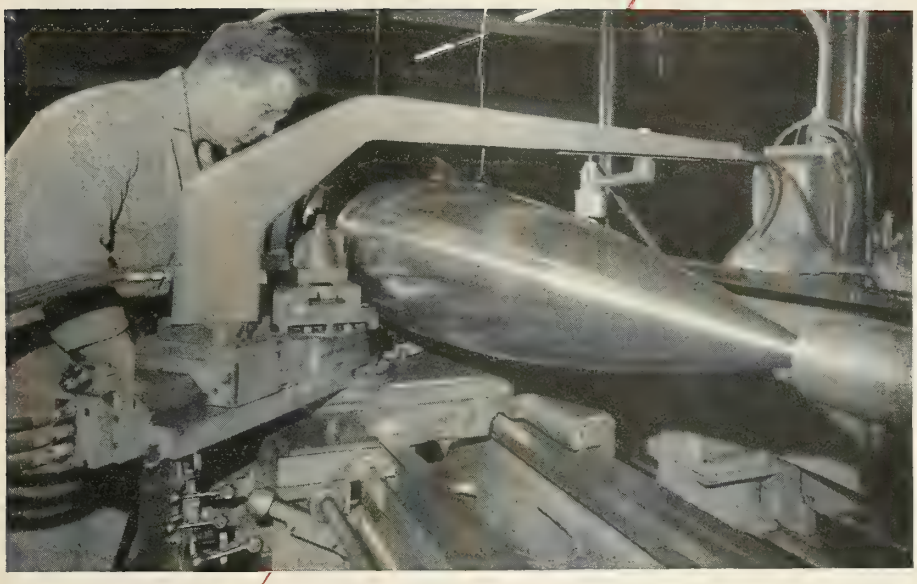
In October 1955 the AAI held an exhibition which drew an attendance of more than 80,000 in its twenty days' run. Exhibits of models, photographs, charts explaining astronautics and the AAI micro-rocket set-up were displayed. Plans have now been made with the Argentine Government to set up an AAI-administered planetarium.

A 36-page review of activities and short articles is published quarterly. An astronautical library is maintained at secretarial headquarters. From time to time the AAI holds special meetings or social functions. An example of these was the overnight trip to the I.A.M.E. factory and the reaction motor proving grounds at Jose de la Quintana, Cordoba.

The AAI played a significant role in stimulating interest which resulted in the establishment of the Astronautics



This conception of an earth satellite was on display at the October 1955 AAI exhibition in Argentina which drew an attendance of 80,000. Note the arrangement of antennae.



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Center at the National University of Cuyo, Mendoza. Founded in 1953 by the Rector of the University, Dr. I. Fernando Cruz, in the Department of Scientific Research, it is believed that this was the first formal recognition of astronautics by a university. Directorship of the Astronautics Center was offered originally to Austrian-born Dr. Ing. Eugen Säenger and his wife Dr. Irene Säenger-Bredt.

The Säengers, widely known in rocket and astronautical circles, were at this time working for the French defense department near Paris. Säenger was formerly director of the German Luftwaffe rocket center at Trauen. Known especially for his technical works including *Raketenflugtechnik*, Säenger and his mathematician wife developed the preliminary design study for the globe-circling rocket bomber.

Unfortunately for the Institute, difficulties prevented the travel of the Säengers to Argentina. The first director was the well known Dr. Ing. Walter Georgii, a close friend of the Säengers.

When Dr. Georgii took over the directorship of the Astronautics Center there were five other Argentine academic institutions with astronautics research interests. They were: Institute of Nuclear Physics, Aerophysics Institute, Mathematics Center, Faculty of Medical Science Tomas Peron, all in Mendoza; and Astronomical Observatory Felix Aquilar, in San Juan.

Professor Georgii's efforts were directed towards a program of upper atmosphere research consisting of a sounding rocket program limited to a modest 60 km. The sudden death in 1954 of the founder, Dean Cruz, and the subsequent departure of Dr. Georgii from Argentina has resulted in the activities of the Astronautics Center virtually ceasing for the moment.

Further IGY activities of AAI include: translation of the MOONWATCH Bulletins for distribution to Spanish-speaking astronomers and IAF Member Societies. This assistance was welcomed. The MOONWATCH Bulletins are published by the Smithsonian Astrophysical Observatory, Cambridge, Mass., for the guidance of trackers.

Early in January Dr. J. Allen Hynek, Associate Director of the Smithsonian Observatory will meet with Tabanera in Buenos Aires to discuss progress. Professor Hynek, of the Ohio State University astronomy department, is on leave to aid Professor Whipple in the IGY optical tracking program.

The AAI is cooperating with the Asociacion Amigos de la Astronomia in organizing volunteer tracking teams. It is expected that at least three groups will be established in Argentina—in Buenos Aires, Rosario and Cordoba ★

International Scene



By Anthony Vandyk

Low price was the prime reason why Japan ordered 200 *Airone* proximity-fused rockets from an Italian company, Polverifici Stacchini of Rome. The *Airone* uses solid fuel and is reported to have a range of 6,500 ft. The Japanese Air Force will test fire the *Airone* rockets from F-86F fighters. Polverifici Stacchini is working on a guided version of the *Airone* to be submitted to the Italian Air Force for evaluation.

•

Vickers-Armstrongs' air-to-air missile has been cancelled by the British government and, as a consequence, the British firm's Australian subsidiary has scheduled the closing down of its guided weapons division. The cancellation was decided because the missile was deemed too complicated and ambitious. Another company is to supply a cheaper and less complex weapon in place of the VA missile.

•

On the lonely rocky Mediterranean island of Sardinia Whitehead-Motofides has been testing its new *A.R.15* liquid-fuel auto-feed rocket. The Italian company, with its headquarters in Leghorn, is understood to have developed the *A.R.15* as an intermediate test vehicle as part of a program to develop a larger, fully guided ground-to-air missile.

•

"Fissile Missile" is the nickname used in the British press for the ICBM with H-bomb warhead under development by the British industry. Main headquarters for work on the British ICBM are at the Royal Aircraft Establishment. The work is under the direction of the Ministry of Supply's Ballistic Missile Division which is headed by 40-year-old Denis Lyons.

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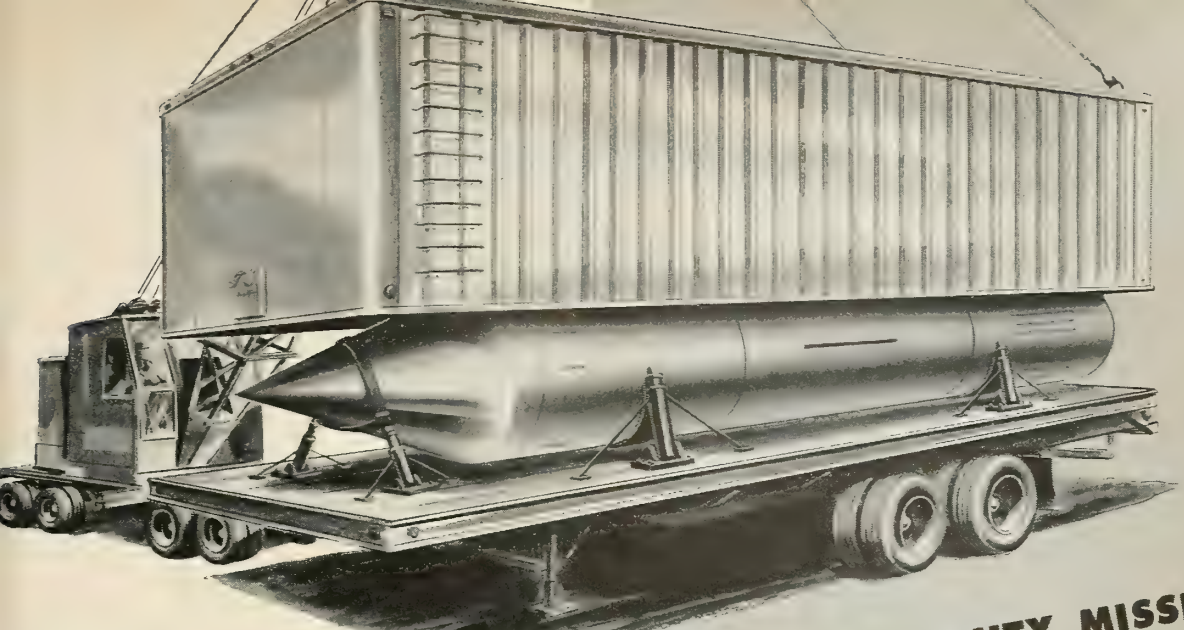
Many European companies are performing research work in the missile field under USAF contracts. One such contract has been awarded to Italy's Centro Italiano per la Propulsione a Reazione, located in Turin. It is understood that the Centro has been asked to develop a missile in the *Sidewinder* category with infra-red guidance.

•

It seems that it may be some long time before Fairey Aviation will be able to mention anything other than the air-to-air *Fireflash* in discussing its missile activities. Board Chairman Roland T. Oulton recently told stockholders that the new projects under way in the firm's Guided Weapons Division are "of long-term nature, due to their complexity." He reported that interest has been shown in the *Fireflash* by NATO countries.

•

The French Navy is becoming very missile conscious. Its 1957 budget provides for the conversion of the transport, Ile d'Oleron, into an experimental missile-launching ship. The 1958 budget will include a 5,000-ton missile-equipped cruiser as well as a 30,000-ton aircraft carrier. The French Navy is putting a lot of faith, and money, inte the Breguet 1050 Dart-powered anti-submarine aircraft which is equipped with missiles. Fifty have been ordered under the 1956 budget, 25 in 1957 and a further 25 in 1958.



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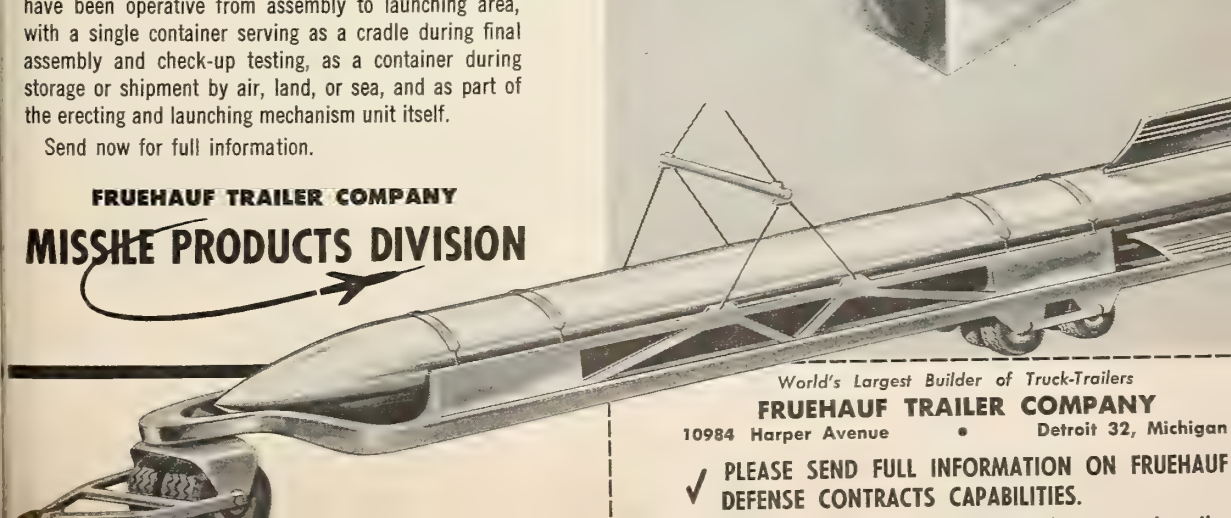
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INDUSTRY SPOTLIGHT

By Joseph S. Murphy

NICKEL FORECAST:

Four More Years of Shortage

Recent decision by The International Nickel Co. of Canada to boost its annual nickel output by some 65,000 tons starting in 1960 should prove welcome news to aircraft, missile and rocket builders.

But before this new found supply becomes a reality, industry can look to a continuing shortage, possibly lasting through 1960, according to market consultant Henry D. Lytton.

Demands for nickel-bearing stainless steels and jet engine super-alloys continued unabated throughout 1956. Future needs for these same metals, plus those of K-Monel and nickel-cobalt alloys being developed to beat the heat problem in supersonic aircraft and missiles, have introduced an unknown quantity into the nickel supply picture.

According to the Lytton report, the true nickel shortage last year was larger than apparent in consumption trends. As a result, stainless steel scrap prices, particularly those of nickel-bearing 18-8 stainless, rode the crest of the shortage and soared as much as 45% between January and the year end.

If 1956 supplies had been adequate, the former government metals specialist adds, steel production alone could have used more than 77,000 tons of newly-mined nickel in meeting present demands and regaining all markets lost during the past 10 years of intermittent shortages. Another 88,000 tons usable by industry pegged the 1956 need at 165,000 tons, before allowances for any government stockpiling.

Against this need stood a late-year Commerce Dept. forecast of 150,000 tons supply in 1956 and 162,500 tons this year.

And just how influential aircraft and missile industry needs may be in shaping the future nickel supply situation is borne out in Lytton's analysis of 1965 demands.

Steel industry, he estimates, will require an additional 12,000 tons and non-steel nickel markets another 10,500 tons, placing minimum 1965 demands 22,500 tons above the 165,000 tons that could have been used in 1956.

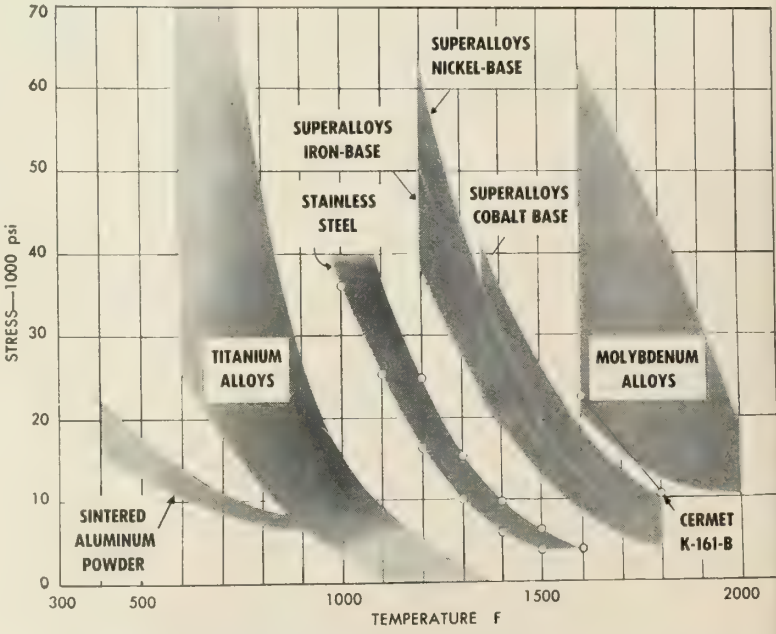
However, the analysis took into account present-day needs of some 12,000 tons of nickel in super-alloy stainless steels for jet engines, but made no provision for expanded civil and military jet needs or those for supersonic and hypersonic aircraft and missile.

Assuming that the first-half 1956 rate of jet engine super-alloy production were to increase four-fold in the next 10 years, says Lytton, total demand for nickel immediately would approximate Office of Defense Mobilization's 220,000-ton goal.

On the world-wide nickel production scene, according to Inco president Henry S. Wingate, the company's plan for increased production coupled with that of other industry sources should bring 1960 nickel output between 300,000 and 312,500 tons. This would represent a jump of about 82,500 to 100,000 tons over 1955's total output of 213,500.

Inco's expansion, involving two new mines in the Mystery-Moak Lakes area of Northern Manitoba, is a $175,000,000 project. When in operation, it will constitute the second largest nickel-producing operation in the world—the largest being the company's present operation in the Sudbury District of Ontario, Canada.

The Manitoba activity, plus programmed output from Sudbury, will raise Inco's 1955 nickel production about 50%, or by approximately 130,000,000 pounds to 385,000,000 pounds. Of this, some 24,000,000 pounds will be regular production to replace present temporary premium-priced production for the U.S. government stockpile, and



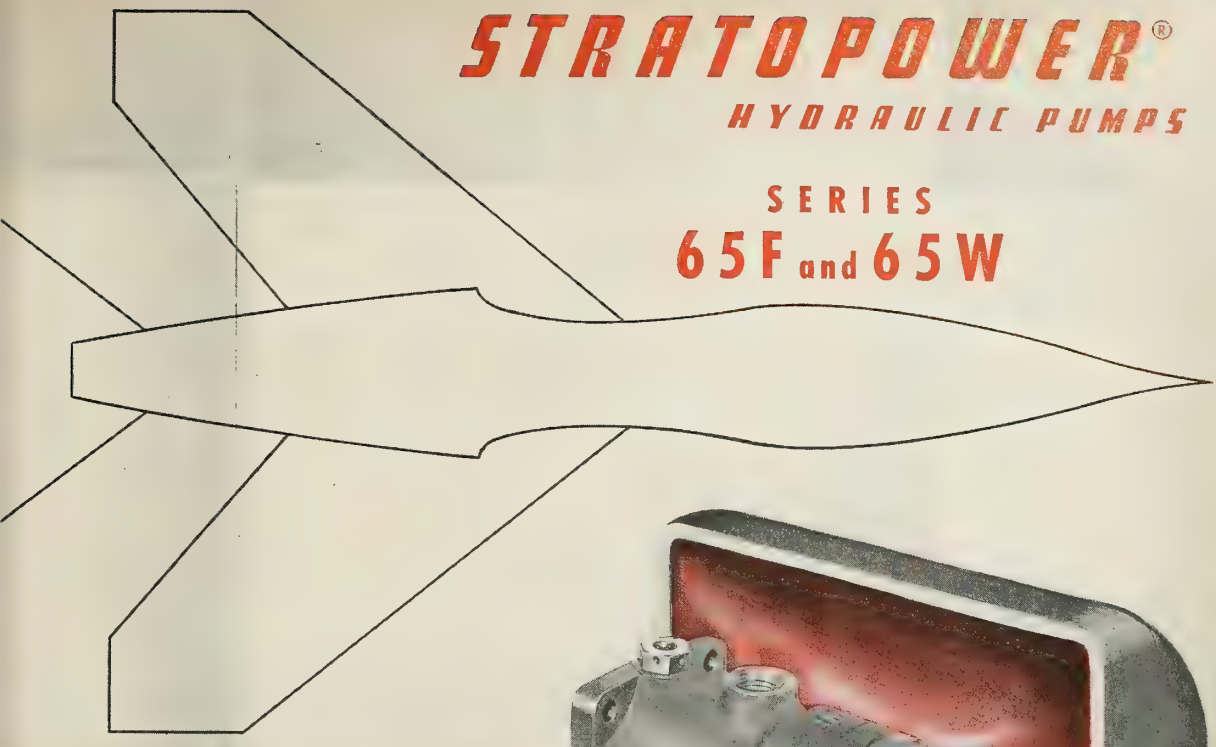
Key role of nickel in development of high speed aircraft and missile structures is evident in these 1,000-hr. stress vs. temperature curves. It extends from present use in nickel-bearing stainless, through the nickel cobalt group.

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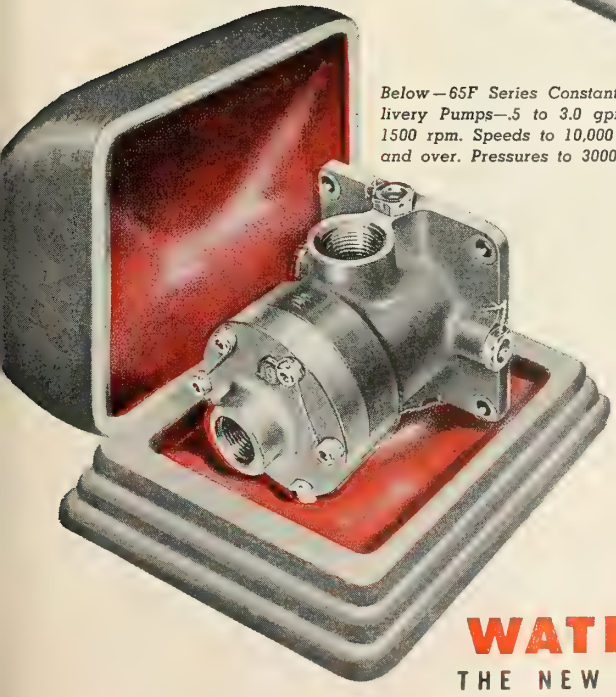
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the balance of 106,000,000 will represent at net increase in total capacity for industry consumption.

The Lytton report, issued prior to the Inco decision, traces nickel consumption over the past 45 years and forecasts demands over the next ten years. Copies of the 81-page document along with a 20-page analysis of 1956 nickel demand are available from Henry D. Lytton, 1326 27th St., Washington 7, D.C., at $10.00.

North American Aviation Surveys Midwest

North American Aviation's Rocketdyne division is making a detailed survey in midwestern states to determine new vendor sources for its Neosho, Mo. plant. H. H. Vaughn, superintendent of manufacturing; R. L. Radford, supervisor of purchasing, outside production, and N. G. Irvin, inspection, form a team currently visiting vendor sources checking capabilities of vendors to produce the intricate valves required at Neosho. Initial valve requirements have been placed with present Rocketdyne suppliers in California. Several other vendor surveys are just now being gotten under way.

Renegotiation Decisions Hit Three Missile Firms

Douglas Aircraft Co. in December became the third major aircraft and missile producer to be judged on the receiving end of excess profits.

The Southern California regional Renegotiation Board recommended that profits of the *Nike* and *Honest John* producer be ruled excessive in the gross amount of $9 million for fiscal year 1953. If upheld by the Renegotiation Board in Washington, this would indicate a possible net refund to the government of $2,240,000.

Company president Donald W. Douglas said the company was not yet informed fully of the basis for the regional recommendation, but maintained that proper consideration of all facts would show its profits were not excessive.

In November, North American Aviation, Inc. was notified by a regional board that its 1953 profits were considered excessive in the amount of $6 million. Allowance for state and federal taxes for this amount would entail a refund of $1.3 million, if upheld.

The third producer, Boeing Airplane Co., is still contesting a decision of the Renegotiation Board that its 1952 profits were $10 million in excess. Boeing comptroller Clyde Skeen, in a recent address, urged that Congress undertake a comprehensive review of current administration of the Renegotiation Act.

Skeen contended that the trend of present administration of the statutory Renegotiation Board, if it continues, will destroy industry incentive and result in less defense per dollar. He noted that if it is Congress' intent to arbitrarily restrict profits, this can be accomplished much more simply than by the complex, time-consuming and expensive process of renegotiation.

Titanium Production Up Sharply This Year

Production of mill products by the titanium industry almost tripled its 1955 volume last year and will more than double its 1956 output this year, according to T. W. Lippert, Titanium Metals Corp. of America.

The TMC sales manager estimates output of finished mill shapes totaled 10.6 million lbs. in 1956 compared to

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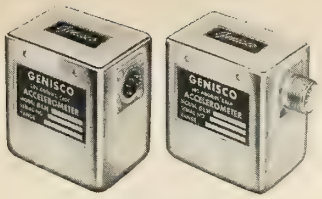
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EDMUND SCIENTIFIC CO., Barrington, N. J.

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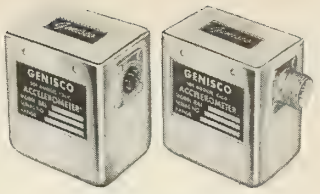
Model GLH

A rugged magnetically damped instrument with low natural frequencies for low range. High-quantity production assures good price and delivery schedules. Available in ranges from ±1 G to ±30 G.



Model DDL

Magnetically damped low-range instrument available in ranges from ±1 G to ±30 G. Ultra-sensitive models supplied as low as ±0.1 G. Certified to MIL-E-5400 and MIL-E-5272A. Especially good in severe shock and vibration applications. An acceleration-sensitive switch version of the DDL is designated as the Model DDS.



Model GAL

Incorporates a variable transformer a-c output with the magnetically damped sensory mechanism of the proven Models DDL and GLH. Superior reliability, life, resolution, and sensitivity. Available in ranges from ±1 G to ±30 G. Range as low as ±0.1 G also obtainable.



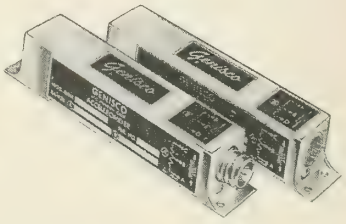
Model GMO

A rugged, miniature, viscous-damped instrument with ranges from ±2 G to ±30 G. Unbalanced-range instruments also available. Medium high natural frequencies.



Model GMT

Basically a Model GMO with internal thermostat-operated heater, assuring maximum environmental stability within the instrument. Damping remains constant with change in ambient temperature.



Model GDM

Miniature double-potentiometer instrument capable of sensing lateral acceleration in two mutually perpendicular planes (e.g., pitch and yaw). Ideally suited for missile and high-speed aircraft flight control systems.

NEW! GENISCO ACCELEROMETERS NOW GOLD PLATED FOR GREATER RELIABILITY

CASES GOLD PLATED INSIDE AND OUT—This new trend in instrument plating has two important advantages over tin plating or fusing. Being the least active metal, gold prevents the formation of crystalline "whiskers" inside the case which could reduce performance and even cause malfunction. Gold plating also assures positive protection against corrosion to the exterior of the case and, because of its excellent solderability, makes possible a more reliable hermetic seal. The new gold plating is available on *all* models at *no extra cost.*

Descriptive data sheets available on all models.
Please send request on company letterhead.

Genisco INCORPORATED

2233 Federal Avenue
Los Angeles 64, California

Circle No. 18 on Subscriber Service Card.



taming the wild blue yonder

We have come a long way since Da Vinci designed his primitive winged machine; an even longer way from Icarus' attempt to imitate birds. Doubtless, there is still a long way to go.

In the years of experiment and achievement that lie ahead, **YARDNEY COMPACT POWER PRODUCTS** *will continue to play important roles. Lighter and smaller than any other batteries, the* **YARDNEY SILVERCEL*** *and the* **YARDNEY SILCAD*** *offer the way to new and higher standards of economy in the size and weight of battery-powered equipment.* * TRADE MARK. WORLD WIDE PATENTS GRANTED OR PENDING.

YARDNEY ELECTRIC CORPORATION

"pioneers in compact power" **40-50 LEONARD ST., NEW YORK 13, N. Y.**

3.8 million in 1955. This year the figure will rise to about 23 million pounds, he said.

Meanwhile, titanium sponge dropped in cost to $2.75 a pound from $3.45 a year ago and $5.00 in 1954.

Convair Gets $29 Million Contract for *Terrier*

Navy has awarded Convair-Pomona division a $29 million contract to produce guidance and control units for *Terrier* missiles. The Navy also confirmed that Convair has entered production with a new version of the antiaircraft missile.

The improved *Terrier* entered production September 1, about two months before phase-out of the original version. The new *Terrier* is basically the same missile with revised engineering features to increase its producibility.

The Convair supersonic surface-to-air missile is now fitted on the cruisers *Canberra* and *Boston* as well as the destroyer *Gyatt*. According to Bureau of Ordnance chief RAdm. F. S. Withington, Navy plans its use on many other destroyer vessel types.

Martin Sees $300 Million In Sales for 1956

Final sales figure at The Glenn L. Martin Co. for the year 1956 is expected to top $300 million, up more than 8% from $272 million in 1955, according to Martin secretary-treasurer W. L. Lucas.

The Baltimore firm, engaged in three major missile projects (*Matador, Lacrosse* and *Titan*) plus the *Vanguard* satellite, also experienced an increase over its backlog of $660 million a year ago.

Missile business at Martin is now almost equal its total volume in aircraft contracts, with the combined missile and aircraft orders representing about 90% of its backlog.

AF to Spend $25 Million For ICBM Training Center

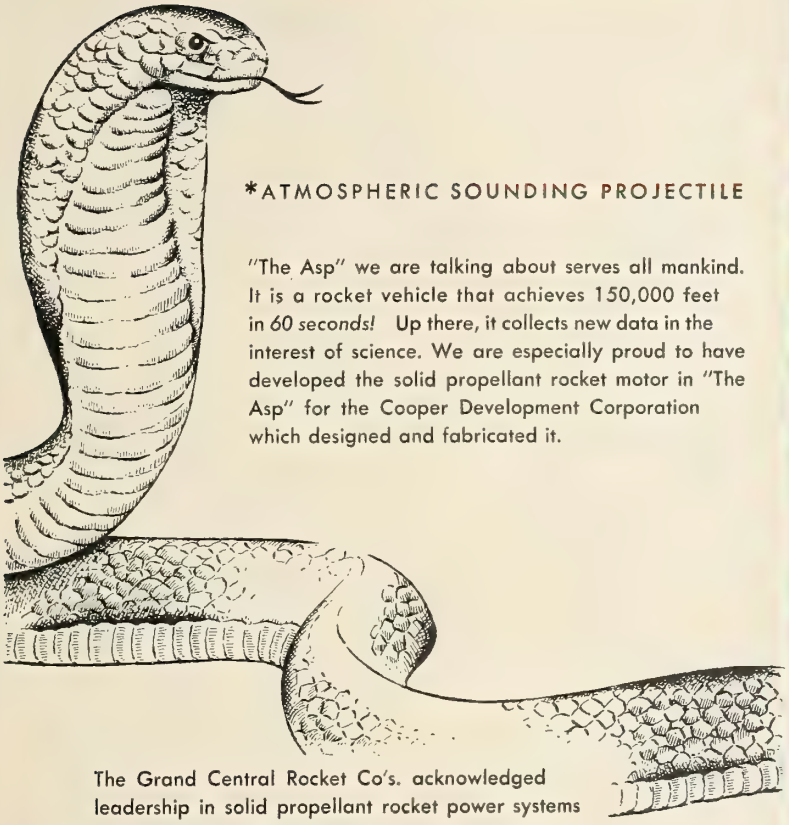
USAF plans to spend about $25 million this fiscal year to modernize and enlarge its first ballistic missile training center, according to Maj. Gen. B. A. Schriever, Western Development Division commander.

With top-level Defense Dept. approval, USAF has taken over Army's Camp Cooke at Lampoc, Calif. and expects the center to be fully operational in about six months.

Design contract to draw up plans has been awarded to Holmes and Narver, Los Angeles architects.

The ASP*

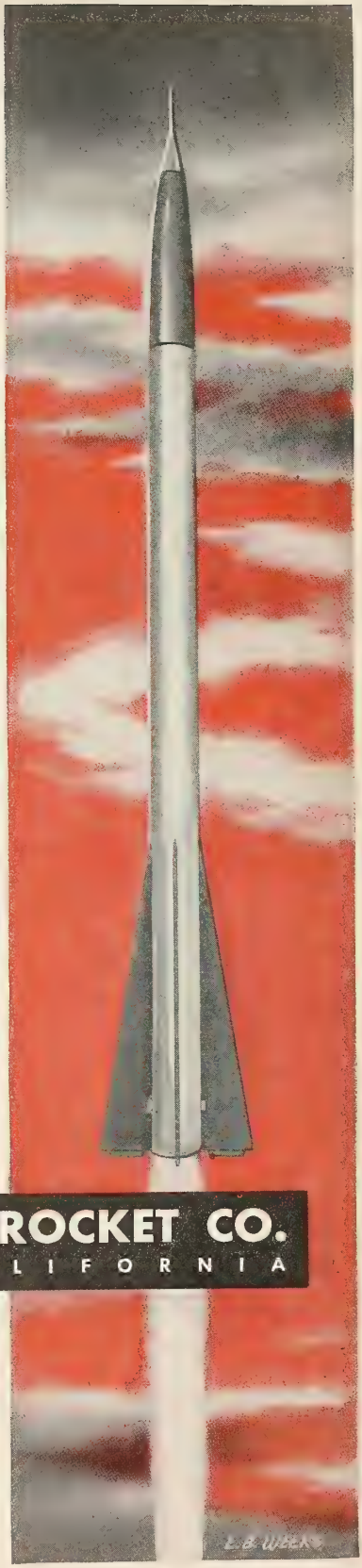
can be friendly!



*ATMOSPHERIC SOUNDING PROJECTILE

"The Asp" we are talking about serves all mankind. It is a rocket vehicle that achieves 150,000 feet in *60 seconds!* Up there, it collects new data in the interest of science. We are especially proud to have developed the solid propellant rocket motor in "The Asp" for the Cooper Development Corporation which designed and fabricated it.

The Grand Central Rocket Co's. acknowledged leadership in solid propellant rocket power systems has attracted the finest engineers. We invite you to join our team.



GRAND CENTRAL ROCKET CO.

REDLANDS, CALIFORNIA

Please Direct Professional Applications
To Leslie Van Dusen, Personnel Manager.

Navy Reorders *Regulus*, Boosts Chance Vought Backlog by $26 Million

New Navy orders for *Regulus I* and *Regulus II* missiles amounting to $26 million have hiked total backlog for that service with Chance Vought Aircraft to more than $500 million.

It marked Navy's second order for *Regulus II, a* previous $12 million contract coming in July 1956. Navy also confirmed that the new *Regulus* is supersonic, although no further details were released.

Regulus II is fitted with Wright J65 on first eight pre-production models, but will use General Electric J79 in remainder. *Regulus I,* which is subsonic, is powered by Allison J33.

Bomarc Mass Order Believed Near

An Air Force order for large quantity production of the supersonic ramjet-powered Boeing *Bomarc* missile is expected this month. The AF move is anticipated in the light of successful firings against B-17 drones at Patrick AFB Missile Test Center following several months of advanced testing.

Also pointing to an early order was the increased activity at Boeing in recent months to select a final site for *Bomarc* production. On November 7 the Seattle firm took option on the Ford Motor Co. plant at Richmond, Calif. and only a month later optioned additional land in San Ramon Valley near Parks AFB.

Although neither option has been exercised, Boeing plan is to establish the new facility as an integrated pilotless interceptor production and assembly plant should the site be selected.

Aerojet Sales Increase 100% Over 1955

Total 1956 sales of Aerojet-General Corp., subsidiary of General Tire & Rubber Co., are expected to reach $140 million, up 100% over 1955, company officials estimate. However, net profit after taxes will rise only 50% over last year as the result of increased activity in cost-plus type development contracts.

Sharp increase in sales was credited to Defense awards to Aerojet's liquid rocket plant at Sacramento, Calif. An even sharper rise in sales is predicted for 1957 resulting from development of the AGN 201 nucleonic reactor by Aerojet's new subsidiary, Aerojet-General Nucleonics Corp.

Industry Highlights



By Fred S. Hunter

Grand Central Rocket Co. is preparing to set up a new rocket engine test facility at a remote location about 15 miles from its Redlands plant. Grand Central picked this particular 1000-acre site because it is part of a large holding originally acquired under a Spanish land grant and still intact. The owners agreed to maintain a two mile buffer zone as a provision of the lease.

The new unit will supplement a six-stand test facility Grand Central now operates in the foothills back of the Redlands plant. Structurally, one of these stands can test rocket engines up to 1,000,000 pounds thrust and two others 500,000 pounds. But Grand Central's plans not to exceed the 100,000-pound thrust level in any firings at the factory site but to go to the country with bigger stuff. Grand Central is on good terms with the folk around Redlands and aims to stay that way.

●

Having phased out on production on the Sperry *Sparrow I,* Douglas now has the *Sparrow III,* on which it is the prime contractor, but this version of the Navy air-to-air missile has not been ordered into production. The Douglas contribution to the Raytheon *Sparrow II* was strictly R and D. It developed the missile airframe, but is not participating in its production. *Sparrow III* guidance is Bendix Pacific.

●

Dan Kimball, president of Aerojet-General Corp., would appreciate it if the government would establish a post office named Aerojet at the location of the company's growing rocket engine plant 15 miles east of Sacramento. There is nothing in the area except the Aerojet people now that the gold dredgers have gone their way, so why not a post office named Aerojet, Cailfornia? We wish Dan luck, but we dunno. Dan is an active Democrat and the post office department is in Republican hands right now.

●

If you can run a lathe or a typewriter, every employment office door in town will swing wide open for you. Next to engineers, most critical personnel shortage on the coast is machinists. Then secretaries. A sign of the times is to note how the proportion of help wanted advertising for missile people keeps growing in the classified columns of the Los Angeles papers. Another sign—one employment agency advertises it has openings paying up to $30,000 a year. And then there's North American Aviation's scheme to solve part of its problem with "week-end" jobs. Example—it hires key punch operators for Saturday work only.

●

Hughes Aircraft, a leader in this work, has 1500 physically handicapped employes at its Tucson plant . . . Everybody was happy to see Lockheed reward Herschel Brown with permanent appointment as assistant general manager of the Missile Systems division . . . The Douglas *Rockaire* sounding rocket is designed for launching from a fighter plane at altitude . . . North American's Rocketdyne division has four Ipsen heat treat furnaces capable of operating up to 2100° F . . . George P. Sutton, an engineering section chief at Rocketdyne and recently elected v.p. of the American Rocket Society, has published a second edition of his book, *Rocket Propulsion Elements,* including much new material.

●

We note that Mauna Loa on the island of Hawaii is one of the 12 official earth satellite tracking stations. Selection of this site, no doubt, was made because of the excellent visibility prevailing in the islands. And what a delightful way to make a lasting contribution to the progress of science, sitting under a palm tree, tracking a missile with one eye and a hula dancer with the other.

Computer Conference Scheduled in New York

Conference on digital computing in the aircraft industry, including techniques used in structural analysis of aircraft and missiles, is being sponsored by New York University January 31 and February 1.

Entire program will be devoted to aircraft industry computer activities with some 25 papers slated for presentation. Write Dr. M. A. Woodbury, NYU College of Engineering, University Heights 53, N.Y. for arrangements.

Link to Open West Coast Facility

Link Aviation, Inc. this month will begin operations in a new research facility at Palo Alto, Calif. intended to permit closer coordination with west coast missile producers.

New laboratory will be situated at 430 University Ave., Palo Alto, and is expected to have an initial staff of 75 employes. Negotiations are also underway for further expansion in Stanford University's Industrial Park.

Link's west coast activities will include work in advanced electronic computer systems, transistor circuits and missile test systems.

NAA Pays $384,000 In C/L Adjustment

Employes of North American Aviation received a 3.2% cost-of-living pay increase effective December 17, adding an estimated $384,000 monthly to NAA's payroll.

Increase affects employes at five company facilities in Los Angeles, plus divisions at Fresno, Calif.; Columbus, Ohio; Neosho, Mo. and Cocoa, Fla.

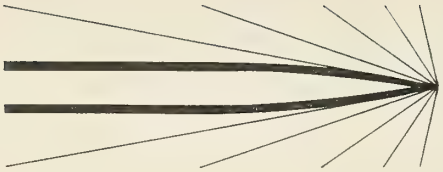
Douglas, NAA Receive Missile/Rocket Contracts

Air Materiel Command has awarded Douglas Aircraft Co., Santa Monica division a $3,650,622 contract for rockets, spare parts and data.

North American Aviation, Inc. received a $2,833,000 award covering new facilities for its guided missile (*Navaho*) program.

Sperry Facility Underway

Newly formed Sperry Phoenix Co. has begun construction of a $3 million, 81,000 sq. ft. plant in Phoenix, Ariz. with target for completion set in August. Company expects to employ about 500 persons in new plant.



MISSILE ENGINEERS

Many new positions are being created at Northrop Aircraft for missile engineers in a wide range of activity: control, guidance, servo, computers, recording, optical, reliability, electro-mechanical, telemetering and electronics. There's an interesting position for you, at your own experience level, with attractive remuneration and steady advancement, in one of the following groups:

GUIDANCE AND CONTROLS, encompassing research and development of advance automatic guidance and flight control systems for both missiles and piloted aircraft. Specific areas of development include: radio and radar systems, flight control systems, inertial guidance systems, instrument servo systems, digital computer and magnetic tape recording systems, airborne analogue computer systems, optical and mechanical systems, and systems test and analyzer equipment.

FLIGHT TEST ENGINEERING SECTION, which plans the missile test programs and establishes test data requirements in support of the programs. The data requirements are predicated on the test information required by the engineering analytical and design groups to develop and demonstrate the final missile design, and are the basis from which instrumentation requirements are formulated.

The analysis work performed consists of aerodynamic, missile systems, dynamics, flight control, propulsion and guidance evaluation. The Flight Test Engineering Section is also responsible for the field test program of the ground support equipment required for the missile.

FLIGHT TEST INSTRUMENTATION SECTION, which includes a Systems Engineering Group responsible for the system design concept; a Development Laboratory where electronic and electro-mechanical systems and components are developed; an Instrumentation Design Group for the detail design of test instrumentation components and systems; a Mechanic Laboratory where the instrumentation hardware is fabricated; and a Calibration and Test Group where the various instrumentation items and systems are calibrated and tested.

For 17 years Northrop Aircraft has pioneered in missile research and development. As a member of this forefront organization in this growing field, new opportunities for full expression of your initiative and ability will always be yours at Northrop.

If you qualify for any of these attractive positions, we invite you to contact the Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., telephone ORegon 8-9111, Extension 1893, or write to: 1015 East Broadway, Department 4600-L, Hawthorne, California.



NORTHROP

NORTHROP AIRCRAFT, INC., HAWTHORNE, CALIFORNIA

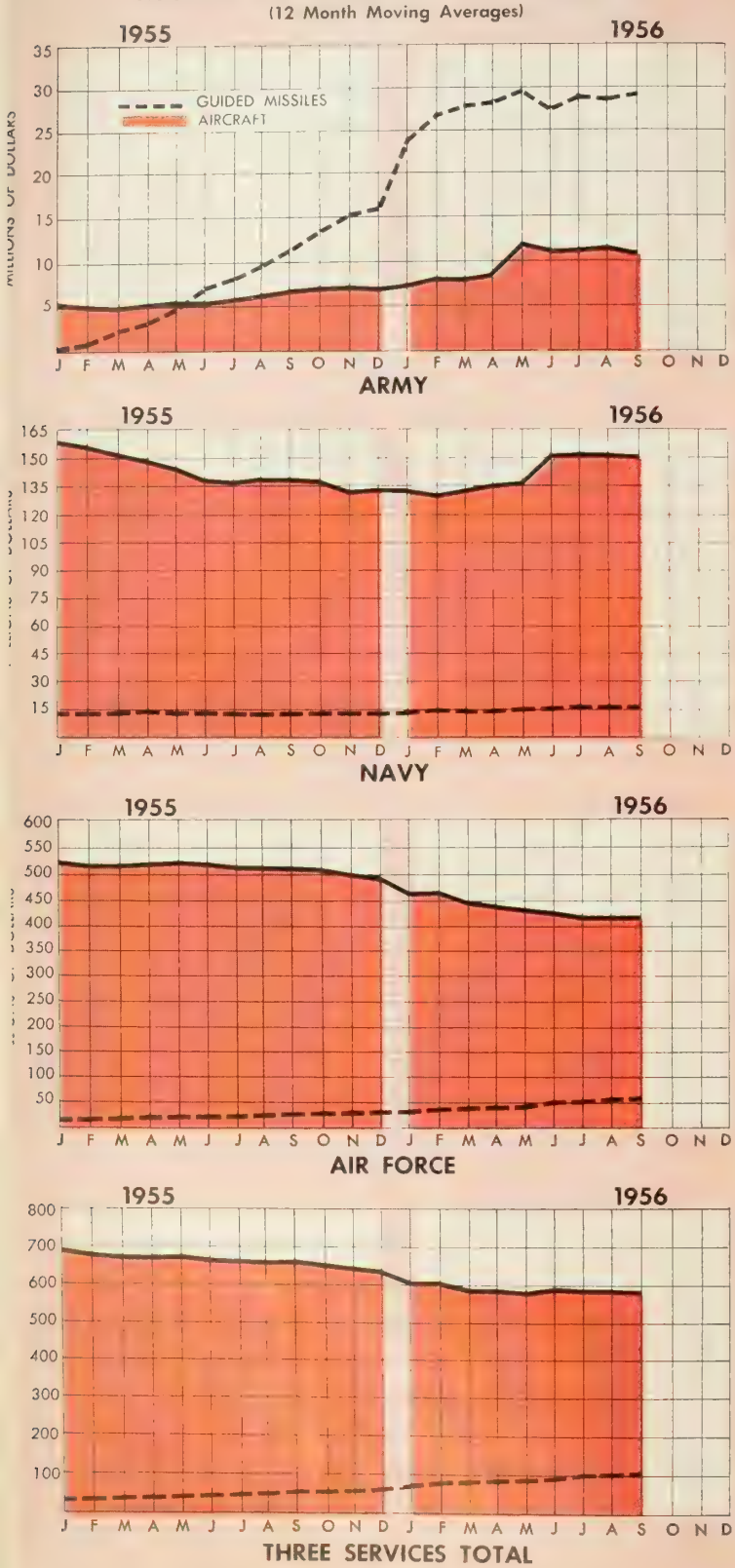
Producers of Scorpion F-89 Interceptors and Snark SM-62 Intercontinental Missiles

5-A-88

INDUSTRY BAROMETER

MISSILE VS. AIRCRAFT EXPENDITURES

(12 Month Moving Averages)



An examination of current Department of Defense expenditures for aircraft and guided missiles reveals that for every $5 spent on aircraft, the Government also disburses $1 on guided missiles and supporting equipment. A twelve-month moving average for the period ending September 30, 1956 shows DOD guided missile expenditures are now 19% of money spent for aircraft. As recently as January 1955 expenditures for missiles were only 5% of aircraft. The trend, shown in the accompanying charts, of spending a greater per cent of procurement money for missiles has been officially acknowledged by the Pentagon.

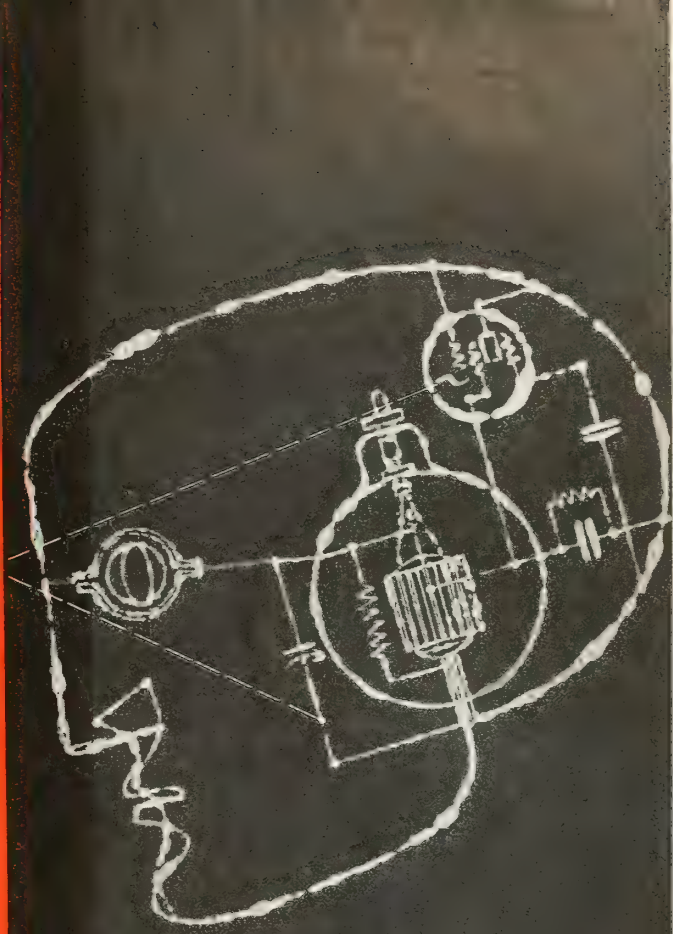
In September of 1956, Reuben Robertson, Jr., Deputy Defense Secretary, stated that the U.S. will spend well over $2.5 billion dollars on missile development and procurement in Fiscal 1957.

The position of the Air Force, as the largest missile procurer of the three services, is especially noteworthy. Col. W. A. Davis, Director, Procurement and Production, Deputy Chief of Staff, Materiel, made the following statement when he appeared before the House of Representatives Military Appropriations Subcommittee in March of '56.

". . . we are integrating missiles into our force structure as replacements for manned aircraft. The effect of these replacements will be minor at first but will grow progressively each year. In 1952, out of our total production money for aircraft and related equipment, only 4% was allocated for missiles. In our fiscal year 1955 buying program, we are applying 12% to missiles. By fiscal year 1959, we expect to use 35% of our production dollars for missiles."

While missile expenditures have increased tremendously in the past few years, the total spent for both aircraft and missiles has experienced relative stability. In January of 1955 a twelve month moving average showed the DOD spent approximately $729 millions for aircraft plus missiles. In June of 1955, the figure was $717 millions. Low point for the period January 1955 through September 1956 was March 1956, when $677 millions was spent. Since March 1956 expenditures have been on the rise. Based on latest Pentagon data (September 1956) aircraft and missile expenditures are at the $698 millions per month level. The year 1957 should find the DOD missile expenditures going well over $700 millions per month level.





HOW TO IMPROVE A MISSILE'S IQ

...'s guided missile is an amazingly sophisticated and ...gent instrument, capable of complex thought and ...e action. Tomorrow's must have an even higher IQ.

To improve a missile's intelligence, Fairchild Guided Missiles Division engineers and scientists have developed radical new concepts for guidance and control, transferring their intelligence into the missile's guidance center.

Through sound research, inventiveness and imagination, FGMD engineers and scientists continue to make great strides in all fields of missile development...putting *more brain-power* into *more missile power.*

FAIRCHILD

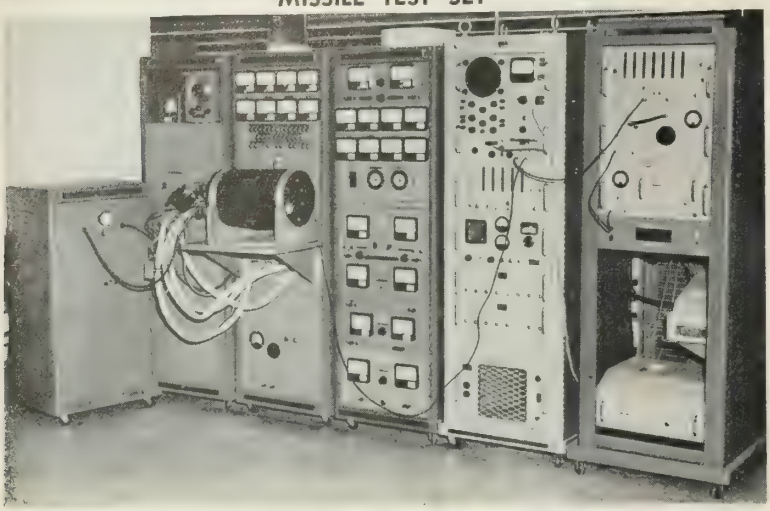
GUIDED MISSILES DIVISION • WYANDANCH, LONG ISLAND, N. Y.

A Division of Fairchild Engine and Airplane Corporation

...WHERE THE FUTURE IS MEASURED IN LIGHT-YEARS!

NEW MISSILE PRODUCTS

MISSILE TEST SET



A semi-automatic programmed test set for use in final testing of missile telemetering packages has been produced. Read-out is in digital form and the set is capable of programming about 200 different measurements.

According to the designers, the set electrically tests a 177-channel FM/FM missile telemetering system in less than an hour and can be operated by non-technical, semi-skilled personnel.

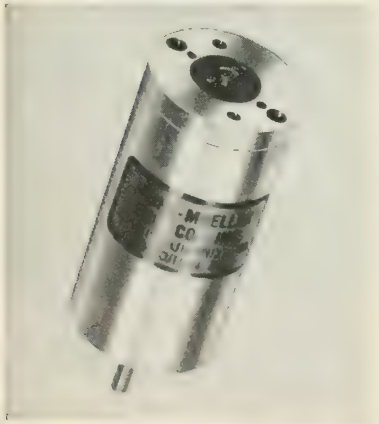
Only one operator is required to initiate the sequence of tests. Carrier frequency, power output, as well as frequency and amplitude of each sub-carrier channel are tested together with analysis of linearity sensitivity and frequency conversion.

A signal simulator rack provides simulated transducer signals. The read-out rack converts signals to digital form and this is printed on paper tape. Separate analysis of individual sub-carriers is permitted.

In addition to "Go No-Go" information, specific data is supplied. Bendix Pacific Division, 11600 Sherman Way, North Hollywood, Calif.

Circle No. 221 on Subscriber Service Card

MINIATURE MOTORS



A series of new miniature d-c motors or generators measure only 1.625 in. long and 0.875 in. in diameter with a shaft diameter of 0.98 in.

Units feature self-aligning sleeve bearings with nylon retainers to assure quiet running. Shafts are hardened, ground and lapped and stators are Alnico TV ring type.

Motors include adjustable brush bracket for accurate speed of voltage output for clockwise or counter-clockwise rotation. Models with 1 in., 1.250 in. or 1.438 in. diameter are also available.

Heinz Mueller Engineering Co., 1906-08 N. Cicero Ave., Chicago 39, Ill.

Circle No. 205 on Subscriber Service Card

SPRAY-ON CERAMIC

New Therm-O-Lab ceramic electrical heating elements developed for aircraft and missile use can be sprayed on surface to be coated and are rated to withstand Spec. MIL-E-5272A vibration tests.

The thin ceramic blanket is rated to perform dependably under operating temperatures up to 500°F. Therm-O-Lab Corp., 6940 Farmdale Ave., North Hollywood, Calif.

Circle No. 212 on Subscriber Service Card

FLUID SYSTEM FILTERS

"Rigimesh," a rigidized wire mesh used in filter elements for aircraft or missile hydraulic, oxygen, nitrogen and helium systems is designed for operating temperatures from —65° to 900°F. Produced by furnace welding the wires of the mesh at all contact points, Rigimesh is said to have working features that permit fabrication by cutting, rolling, corrugating and welding without losing uniformity of mesh openings.

According to its producer, filter elements have been adapted to operating pressures from vacuum to 10,000 psi and with particle size retention ratings from two to 2,000 microns. In one application, a Rigimesh laminate is used to line combustion chambers and afterburners of turbine engines so they can be transpiration cooled.

Aircraft Porous Media, Inc., c/o Pall Filtration Companies, 30 Sea Cliff Ave., Glen Cove, N. Y.

Circle No. 213 on Subscriber Service Card

MISSILE CABLE

Electronic cable with stable performance characteristics under temperature conditions ranging from —85° to 410°F has been announced. The manufacturer claims normal operation of the new cable under all present conditions of missile and rocket performance.

Teflon insulated conductors and a sheath of specially compounded silicone rubber have been used in a new design. Each conductor is free to move within certain limits and the entire cable core is allowed limited movement within the jacket.

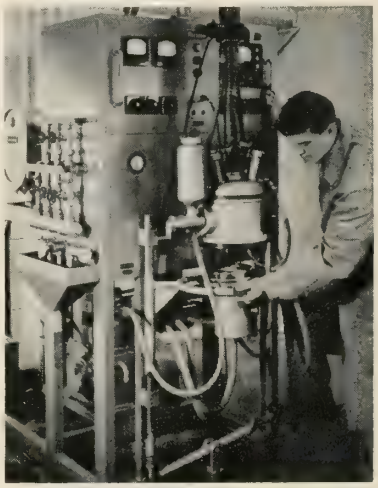
A continuing automatic adjustment of these movements is claimed to allow flexing far beyond the limits of any other cable type over the stated temperature range: Conductors can be supplied in many color combinations for identification.

Douglas Roesch Division, Hall-Scott Inc., 2850 Seventh St., Berkeley, Calif.

Circle No. 220 on Subscriber Service Card

VACUUM ARC-MELTING FURNACE

A new laboratory arc-melting vacuum furnace that simulates conditions in a large production furnace is now available. The VA-L200C furnace is manufactured by W. C. Heraeus in West Germany and distributed in the U.S.



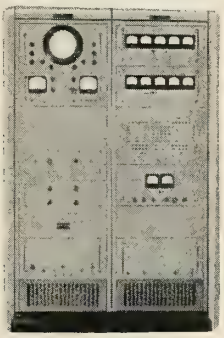
The furnace uses interchangeable consumable and non-consumable electrodes. It can handle high melting point metals such as nickel, iron copper and many metallic carbides and borides. Inert atmosphere or vacuum operation to 5 x 10 —4 mm hg is possible, and melts of a few ounces to several pounds can be handled.

The furnace has a water-cooled

Pulse Width Data Systems

THOMAS S. MEDEROS, JR., Sales Manager
Applied Science Corporation of Princeton
Princeton, New Jersey

A PW data system is a grouping of equipment which uses the techniques of time division multiplexing and Pulse Width coding to put a number of voltages representing physical quantities, into a form which permits transmission over a single circuit or link, or recording on a single channel or track. The system also provides for the separation and identification of the previously multiplexed data channels and decoding back into voltages, which are used to provide visual display, graphic records, input to data processing equipment or control functions.



M SERIES PW GROUND STATION

Separates and reduces all data channels in real time. Operates on signals from standard airborne set, FM/FM subcarrier, or magnetic tape recorder.

In a PW system, the intelligence is conveyed by the pulse duration rather than amplitude, and therefore the transmission medium is not required to have amplitude linearity but only the ability to discriminate between two states which may be called "on" and "off" or "mark" and "space."

Operation

The basic functional units required in any PW system are transducers, a commutator with suitable driving device, a keyer, an RF transmitter, and data reduction equipment for converting the PW data signals into usable form.

Since the PW data system requires that input signals should be in the form of voltages, suitable transducers capable of converting physical quantities into voltages are used. Present ASCOP PW multicoders operate from signals in the range of 0 to + 5 volts, and low-level equipment is now available with sufficient sensitivity to accommodate inputs in the low millivolt range.

The time division multiplexing is accomplished by a motor-driven rotary sampling switch or commutator. Standard sampling rate is 900 samples per sec, and commutators are now available for operation at 30 RPS over 30 points, 20 RPS over 45 points, and 10 RPS over 90 points. Since two points of the commutator in any of the systems are left unconnected, to provide a gap in the pulse train for "frame" identification, the existing numbers of channels available for data and references are 28, 43, and 88, respectively.

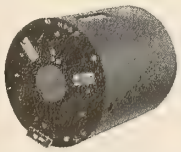


F SERIES MISSILE SETS

Samples up to 43 data sources. This rugged equipment is sealed and pressurized to withstand high altitudes, operation and temperature extremes.

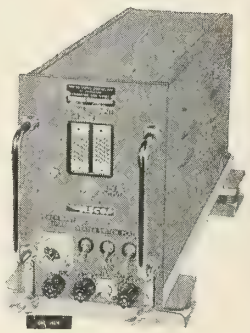
System linearity is determined by the transfer characteristic of the keyer, from volts to Pulse Width, and the linearity of the translator back into volts. A typical ASCOP Pulse Width data system does not deviate from linearity between the scale end points, by more than 0.5 per cent. The total system drift, from any cause, is less than ±0.5 per cent of full scale. Since system levels are maintained by an automatic electronic servo, this degree of stability is maintained over periods of days or weeks, and is accomplished without any warm-up time.

With the stairstep type of electrical output provided by the M Series ground station, it is generally conceded that 6 samples per cycle of the highest data frequency component present allow visual interpolation of output records to better than 1% accuracy. This means that any channel of a 30 × 30 system can reproduce 5 cps data. The frequency response of one or more data channels in the system can be increased by a factor of 2, 3, 4, or more by increasing the effective sampling rate. This can be accomplished by applying the same transducer output to a corresponding numbers of commutator contacts, and making similar provision during decommutation.



SPECIAL MISSILE SET

ASCOP-designed for a customer.



D SERIES PW MULTICODER

For aircraft, mobile or other applications where recovery or continued use is practical and where space and weight are not critical. Samples up to 43 data sources.

Uses

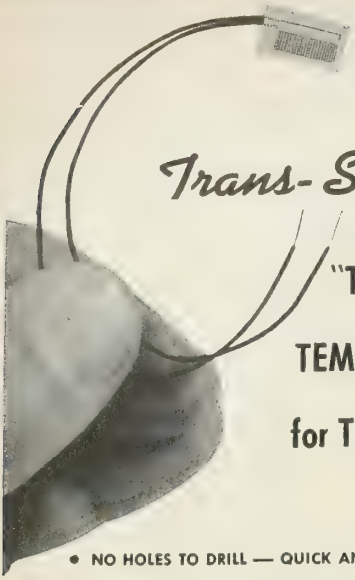
At present, most PW data systems are used for recording experimental test data from missiles and aircraft, where hazard, space limitation, and volume of data to be gathered make the use of a human observer impossible. Measurements of such quantities as the temperature, pressure, strain, altitude, acceleration, flow rate and position are made at rates thousands of times faster and much more accurate than could be done by visual observation and manual recording.

Additional application is also found in experimental test work where hazard and space are not limitations, but where the total volume of data require both high speed automatic measurement and recording. Engine test stands, reactors, and complex electronic equipment are typical devices whose testing requires the automatic measurement and recording of large numbers of physical properties.

PW data systems have been used where many measurements must be transmitted and displayed in easily interpreted form, as in the case where a pilot on the ground must rely on display instruments while he controls a drone aircraft, or in the case where the flight test engineers on the ground must observe conditions in a piloted aircraft in order to insure the safety of the pilot.

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Circle No. 15 on Subscriber Service Card.



NEW

Trans-Sonics*

"TAPE-ON" SURFACE TEMPERATURE RESISTORS

for Temperature Telemetering

- NO HOLES TO DRILL — QUICK AND EASY "TAPE-ON" INSTALLATION
- OUTPUT UP TO 5 VOLTS WITHOUT AMPLIFICATION
- AVAILABLE IN VARIOUS RANGES FROM −300° to +400°F.
- RESISTANCE CHANGE OF 100 OHMS OVER SPECIFIED RANGE

Trans-Sonics Type 1371 "Tape-on" Surface Temperature Resistors are precision resistance thermometers with a platinum resistance winding as the sensing element. They may be applied to *any surface* whose temperatures are to be measured. In a commutation circuit, they modulate standard telemetering transmitters without amplification. The new Type 1371 "Tape-on" Surface Temperature Resistors may be added to an installation using other Trans-Sonics temperature transducers without any further circuitry modification. Each resistor is furnished with two 6" long fibreglas-covered constantan leads. Write for Bulletin 1370 to Trans-Sonics, Inc., Dept. 9.

*Reg. Trademark

SPECIFICATIONS

SIZE: ¼" x 5/16"

Accuracy: ±2% of full scale range

Precision: ± 0.5% of full scale range

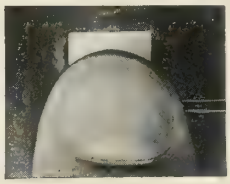
Maximum Continuous Current: 20 ma rms (averaged over 1 second)

Environmental Operation Conditions

Vibration: 1" double amplitude, 0 to 22 cps ± 25g, 22 to 2000 cps

Shock: 100g in any direction, per paragraph 4.15.1 of MIL-E-5272A (10 milliseconds shock)

Instant Installation



As easy to apply as a thumb print.

For Transducers, See Trans-Sonics

Trans-Sonics, Inc.

P. O. BOX 328 LEXINGTON 73, MASSACHUSETTS

stainless-steel chamber with two windows for observing the crucible. A screw-type feeding device is provided. Height of the electrode head is adjustable electromechanically with push button operation. A Roots-type mechanical high vacuum pump with a speed of 950 cubic feet per minute, and which does not have an oil seal is used. Rochester Division, Consolidated Electrodynamics Corp., 1775 Mt. Read Blvd., Rochester, N.Y.

Circle No. 227 on Subscriber Service Card

SECTOR POTENTIOMETERS



A new line of sector potentiometers especially engineered for missile and aircraft systems is available. Models are designed to measure angles from zero to a maximum of 90° shaft rotation. Accuracy is rated at 0.5 percent and resolution to 0.10°.

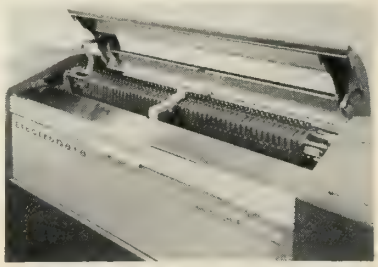
All-metal construction is used together with high temperature insulation for temperatures up to 300°F. The units feature resistance to severe environmental conditions of shock, vibration and temperature and meet explosion-proof requirements.

All three models are available with shaft extension from either side and with terminals or cables, singly or in ganged units. Humphrey, Inc., 2805 Canon St., San Diego 6, Calif.

Circle No. 216 on Subscriber Service Card

ELECTRONIC FILING SYSTEM

An electronic filing device that uses short lengths of magnetic tape to provide storage and rapid access of records has been announced. The new DATAFILE segmentizes information by eliminating conventional tape reels.



According to the manufacturer, the new system supplies 10 times the maximum file capacity of any other data processing system equipment now available. Each unit stores 2-million characters, and up to 10 units can be integrated in one compute system.

Fifty 250-feet tapes are used and information is calibrated into addressable blocks of 200 characters each. The tapes move back and forth over guide rails at 60 inches per second.

Twin read-write heads are propelled beneath the tapes and stop at designated

Circle No. 22 on Subscriber Service Card



what is grey matter worth?

For the engineer or scientist who has enough to make him different, *grey matter* is worth a rewarding life of creative achievement in a working climate where ideas are King...and the benefits measure up to the man and his mind.

For 56 years Firestone has grown on *grey matter*—in Research, Development and Production. Now, simply, we need additional *grey matter* for such Firestone "firsts" as the "Corporal" surface-to-surface ballistic missile. Here are just a few of the Engineering activities in which Firestone needs more *grey matter:*

Electronics Systems
Mechanical Systems
Propulsion Components
Flight Simulation
Mechanical Structures and Dynamics
Stress Analysis
Metallurgical Lab

If you're the man with extra *grey matter* who wants the chance to really use it, write us today. We'll put you in touch with a Firestone man who has your kind of *grey matter*, too.

Firestone

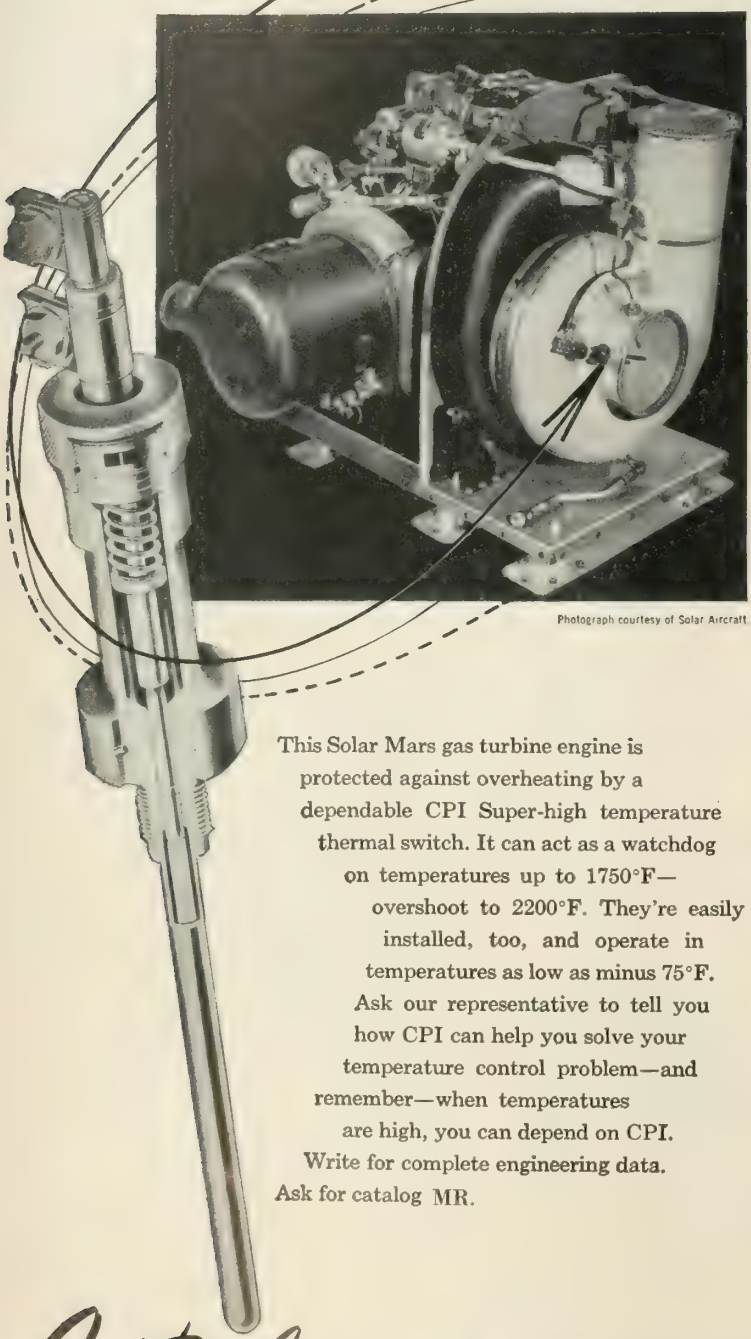
GUIDED MISSILE DIVISION

RESEARCH • DEVELOPMENT • MANUFACTURE

"Find your Future at Firestone"—Los Angeles • Monterey

WRITE: SCIENTIFIC STAFF DIRECTOR, LOS ANGELES 54, CALIF.

no overheating here



Photograph courtesy of Solar Aircraft

This Solar Mars gas turbine engine is protected against overheating by a dependable CPI Super-high temperature thermal switch. It can act as a watchdog on temperatures up to 1750°F—overshoot to 2200°F. They're easily installed, too, and operate in temperatures as low as minus 75°F. Ask our representative to tell you how CPI can help you solve your temperature control problem—and remember—when temperatures are high, you can depend on CPI. Write for complete engineering data. Ask for catalog MR.

Control products, inc.

HARRISON, N. J.

Circle No. 25 on Subscriber Service Card

positions to read or write 1 to 100 blocks of information at 46 milliseconds per block. Storage is in decimal form.

Electro Data, division of Burroughs, 460 Sierra Madre Villa, Pasadena, Calif.

Circle No. 226 on Subscriber Service Card

SUBMINIATURE RELAY

New VG series of relays developed for aircraft and missile applications have a vibration rating at 15 g's from 55 to 2,000 cycles per second. Shock rating is 100 g's.

The VG relays, designed to meet Spec. MIL-R-57570 shock test II, are in the subminiature class. Relays measure less than ¾ cu. in. and weight is 1.3 oz. with a DPDT arrangement. Operating range is —65°C to 85°C and units with 125°C rating will be supplied on request.

Coil specifications call for standard operation at 24-29 volts d-c and maximum coil voltage is 38 volts d-c continuous with pull-in voltage rating at 18 volts maximum over the temperature range. Operating time is 6 milliseconds at 26.5 volts.

Life performance of VG series is said to be at least 100,000 operations at rated load. Elgin National Watch Co., Electronics Div., Elgin, Ill.

Circle No. 206 on Subscriber Service Card

PULSE GENERATOR

A new pulse generator is available that is completely transistorized. Completely self-powered by a 22½ volt battery with a useful life of 450 hours, the generator provides a pulse length from 0.5 to 3 microseconds.



Positive and negative pulses are continuously variable from zero to full amplitude to a 20 volt peak into an 800 ohm load. Rise and decay time is rated at 0.1 microseconds or less; tilt and overshoot at less than ±2%.

Repetition rate on internal sync is from 50 to 5,000 pps, and on external sync from 0 to 5,000 pps. Model 502 generator is housed in a case measuring 8½ x 5 x 4½ inches. Cubic Corp., 5575 Kearny Villa Road, San Diego 11, Calif.

Circle No. 222 on Subscriber Service Card

ROCKET ENGINE HEAT EXCHANGER

An all-aluminum heat exchanger developed for rocket engine propellant testing at Reaction Motors, Inc. has a design temperature range from +100° to —325°F.

In the tests, liquid nitrogen will be vaporized in the shell side of the combination shell and tube unit at —320°F in order to cool liquid oxygen passing through the tubes at about —285°F.

Wanted!

Engineers who will accept the challenge of the most urgent program in the free world today...

Long Range Guided Missiles



Ten years ago there was only a handful of men in the country who said it could be done. Today, more and more engineers—their technological noses scenting the fact that engineering history is in the making—are picking up the gauntlet of the greatest engineering challenge American ingenuity has ever faced—the race against time and the phenomena of long range guided missiles.



Dr. E. R. van DRIEST, Chief Scientist, is nationally recognized for his work in aerothermodynamics. He has a BS, Case Institute of Technology; MS, University of Iowa; Ph.D., Cal Tech; and Sc.D, Technisch Hochschule, Zurich, Switzerland. Around his home, in Whittier, he finds ideal opportunities for the pursuits he and his family like best—horseback-riding, archery and other outdoor activities—perfect complement to the absorbing mysteries of his work.

Research and development that would ordinarily take years is today—of necessity—being telescoped into months. Problems of aerodynamics, thermodynamics, high temperature materials, aeroelasticity—that a decade ago were only theory in textbooks are today being solved. What's more, the production techniques necessary to turn these solutions into hardware have been evolved.

Major Missile Center

One of the major centers of this activity is North American Aviation's Missile Development Division. In 1945 North American started a program of research and development in this field. As far back as 1948, the first NATIV—North American Test Instrument Vehicle—streaked to trajectory altitude of 10 miles. One result of this type of pioneering was complete weapons system responsibility for the Air Force SM-64 Navaho Intercontinental Guided Missile—a gigantic task embracing almost every field of engineering.



JIM THOMPSON's career in missile engineering at North American began in 1951. Today, Jim is Group Leader of Flight Instrumentation at the Missile Test Facility, Patrick Air Force Base, Florida. The tropical climate there is ideal for his favorite sports—fishing and golf.

Progress Grows Apace

We can't give details here, or describe facilities, solutions, flight tests. But we *can* tell you this: a new engineering chapter is being written. It is reaching its climactic phase. There will never be a better time for you to become a Missile Engineer.

Are You This Kind of Man?

Can you break with tradition... leave conventional methods behind... and explore the unknown with the faith that in every obstacle lies the seeds of new successes?



MANUEL C. SANZ, Chief of Materials Research, found unique scope for his special talents at North American. This Chemical Engineer, with a Masters in Physics and Chemistry, is named as the inventor in a patent on the famous Chem-Mill Process. His son leads a Los Angeles school band—with a chem-milled baton!

If You Join These Men, We Promise You

a management climate which stimulates personal growth—and rewards it with responsibility, professional recognition and material benefits limited only by your own abilities. Your own academic stature can be constantly enlarged with our Educational Refund Plan—and some of the nation's finest universities are close at hand.

Write today for full particulars. If you're the man we're seeking, we'll be glad to arrange a personal interview *where you are now residing.*

Contact: Mr. M. Brunetti, Engineering Personnel Dept. 91 MAR
Missile Development Division, 12214 Lakewood Blvd., Downey, California.

NORTH AMERICAN AVIATION, INC.

EXCEPTIONAL OPPORTUNITIES FOR SCIENTISTS AND ENGINEERS

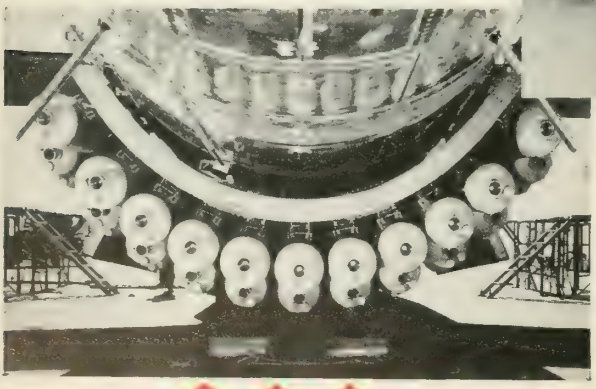
in rocket development at Phillips Petroleum Company



The Rocket Fuels Division of Phillips Petroleum Company operates Air Force Plant 66, a multi-million dollar plant with modern facilities for research, development, testing and manufacture of solid propellant rockets. Exceptional opportunities and key positions are now open to scientists and engineers of proved experience and ability. Challenging opportunities are also available to recent technical graduates, with or without experience. Phillips Petroleum Company is a progressive, diversified company with assets of more than one billion dollars and an already *established reputation* in the rapidly expanding rocket field.

You are invited to write to our Technical Personnel Office, Rocket Fuels Division, Phillips Petroleum Company, McGregor, Texas. Your résumé will receive prompt, confidential attention. Interviews will be arranged for qualified applicants.





Booster Type Rockets by Phillips 66

Above. Giant PUSHER rocket, made from low cost, petroleum-derived materials gives tremendous thrust for short durations.

Left. The M15 JATO was the first of its kind to meet rigid Air Force performance tests. (Boeing Airplane Company photo).

Phillips 66

Rocket Fuels Division

PHILLIPS PETROLEUM COMPANY

McGregor, Texas

NEW EEMCO MOTOR

for new missile

. . . another example of the versatility of the nation's leading producer of motors and actuators for jet aircraft and missile systems.



SPECIFICATIONS FOR TYPE D-855

Type: DC motor with integral gear reduction
Terminal voltage: 24
Horsepower: 4.8 at 200 amps
Output RPM: 2600 minimum
Duty Cycle: 10 min. on, 30 min. off
Ambient temperature range: —65°F. to 250°F.
Minimum starting torque: 300% of running torque
Mounting pad: AND 20001
Cooling: Fan cooled with open thru ventilation
Weight: 17¾ pounds

EEMCO TYPE D-855, a DC motor with integral gear reduction, was designed for use in missiles of the latest concept. Like all **EEMCO** motors, as well as **EEMCO's** rotary and linear actuators, it packs maximum performance into minimum dimensions and weight. With a terminal voltage of 24, Type D-855 produces 4.8 HP at 200 amperes with a minimum RPM output of 2600. Duty cycle is 10 minutes on and 30 minutes off, with minimum starting torque at 300% of running torque. Ambient temperature range is —65° to 250° Fahrenheit. Type D-855 is fan cooled with open thru ventilation.

EEMCO has had many years experience in the exclusive design and manufacture of airborne motors and actuators. As a result, **EEMCO** is thoroughly skilled and equipped to produce these vital components that must operate unfailingly under the extreme environmental conditions encountered in today's supersonic aircraft and missiles. Thus **EEMCO's** extensive specialization in this field is playing an important part in the reliability of the most modern air weapons now being produced for the nation's defense.

Electrical Engineering and Manufacturing Corp.

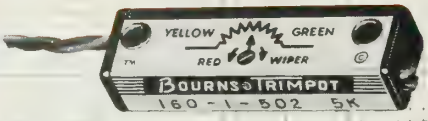
4612 West Jefferson Boulevard
Los Angeles 16, California
Telephone REpublic 3-0151

Designers and Producers of Motors, Linear and Rotary Actuators . . . Exclusively!

SUBMINIATURE TRIMMING POTENTIOMETERS FOR THE

HOT SPOTS

IN YOUR ASSEMBLIES



BOURNS *Model 160*

TRIMPOT®

—new high temperature, high power design





This instrument operates reliably in high ambient temperatures, or wherever closely massed components generate localized hot spots. The TRIMPOT will withstand temperatures up to 175° C. (347° F.) with unimpaired efficiency. Lead wires are Teflon insulated. High power dissipation— 0.6 watt at 50° C. (122° F.)

You'll find every outstanding feature of the original Model 120 TRIMPOT—standard of the industry—built into the Model 160. 25-turn adjustments are made with a screwdriver on the slotted shaft. The shaft is self-locking, to provide stable settings. Resistance element is precision wound with low temperature-coefficient resistance wire. Unit withstands severe shock, vibration and acceleration. To assure its dependable performance under extreme environmental conditions, Bourns designed the Model 160 TRIMPOT to meet or exceed rigid government specifications.

Write for new descriptive literature.

BOURNS LABORATORIES

General Offices: 6135 Magnolia Avenue Riverside, California
Plants: Riverside, California—Ames, Iowa

COPR 8-

Shell has an inside diameter of 32 in. and the tubes are ¾ in. diameter.

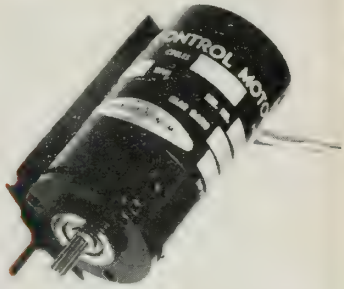
Aluminum was employed throughout the heat exchanger because of its high Charpy impact values at low temperatures. Plain or mill steel, at these temperatures, would be extremely brittle under impact. Design operating pressures are 50 psi on the shell side and 150 psi on the tube side.

The Griscom-Russell Co., Massillon, Ohio.

Circle No. 214 on Subscriber Service Card

MINIATURE CLUTCH

New high performance miniature motor-gearhead clutch classed as Bureau of Ordnance Size 10 has a maximum length of 1¾ in. and weighs only 2.1 oz. Clutch is designed to operate directly from either 115 or a 26 volt line source with protection of gearing and loads supplied by an integral slip clutch.

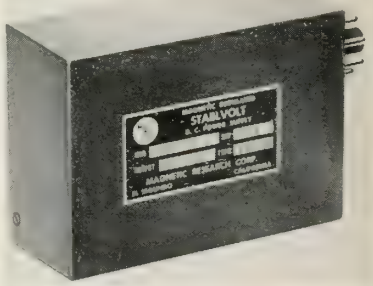


Unit design includes motor and gearhead enclosed in a common aluminum housing. Its use as a control element gains in significance under conditions of high stall torques resulting from use of high gear ratios, the manufacturer says. Servomechanisms, Inc., Mechatrol Div., 625 Main St., Westbury, L. I., N. Y.

Circle No. 212 on Subscriber Service Card

TELEMETERING POWER SUPPLY

A new 22.5 volt dc power supply for various telemetering and instrumentation applications has been announced. The MRP22-1 unit operates from a standard 400 cycle supply with an input voltage of 95-135.



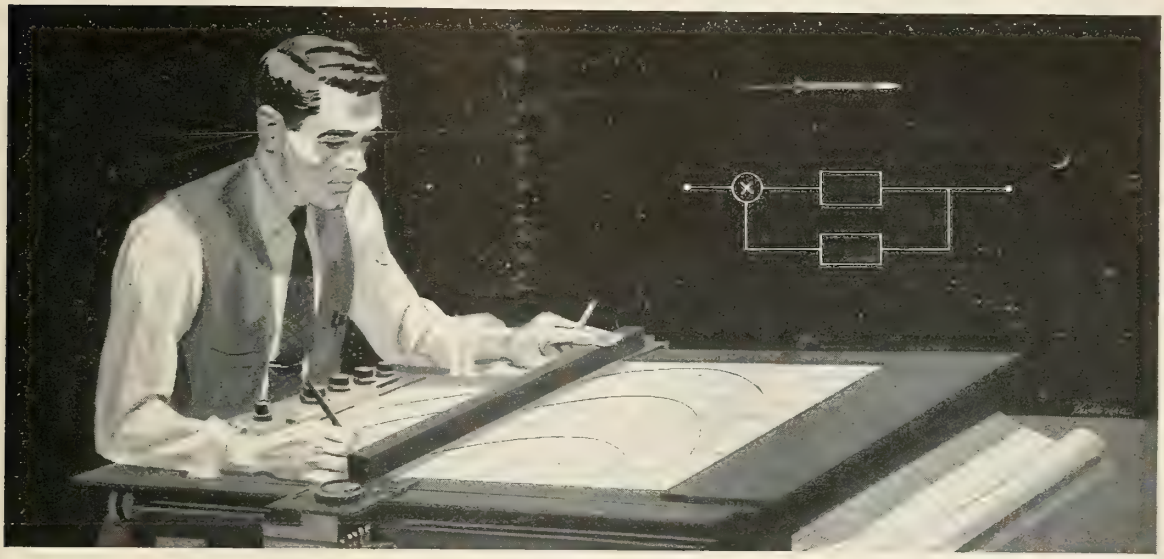
Said by the manufacturer to provide transient free, short circuit-proof performance, the units use dual magnetic regulation providing smooth output and high response speed and provide O-100 milliamperes. The supplies are housed in hermetically sealed steel cases with thermosetting plastic impregnation and measure 3½" x 1½" x 2½". Connector

Circle No. 3 on Subscriber Service Card

Notable Achievements at JPL

MISSILE GUIDANCE AND CONTROL... In applying advanced servo and noise-theory techniques to missile control systems, JPL has led and advanced the field of missile guidance.

Among specific achievements are the application of Wiener RMS methods to multiple-input, multiple-loop servos, and matching missile trajectory to missile control transfer function for optimum accuracy.



Research in Guided Missile Technology

JPL JOB OPPORTUNITIES ARE WAITING FOR YOU TODAY
in these fields

RADIO GUIDANCE
MICROWAVES
SYSTEMS ANALYSIS
GUIDANCE ANALYSIS
APPLIED PHYSICS
ELECTRO MECHANICAL
INSTRUMENTATION
INERTIAL GUIDANCE
TELEMETERING
PACKAGING
MECHANICAL ENGINEERING

The Jet Propulsion Laboratory is an organization devoted entirely to scientific research and development. Covering an 80 acre area in the rising foothills of the San Gabriel mountains, north of Pasadena, it occupies an ideal location close to residential districts.

The working staff of the Laboratory consists of about 1250 people, all employed by the California Institute of Technology. The various projects are conducted under continuing contracts with the U. S. Government.

The prime objective of JPL is obtaining basic information in the various sciences related to missile systems development and in all phases of jet propulsion. Underlying the entire Laboratory activity, a major continuous program of fundamental research in the physical sciences is constantly in progress.

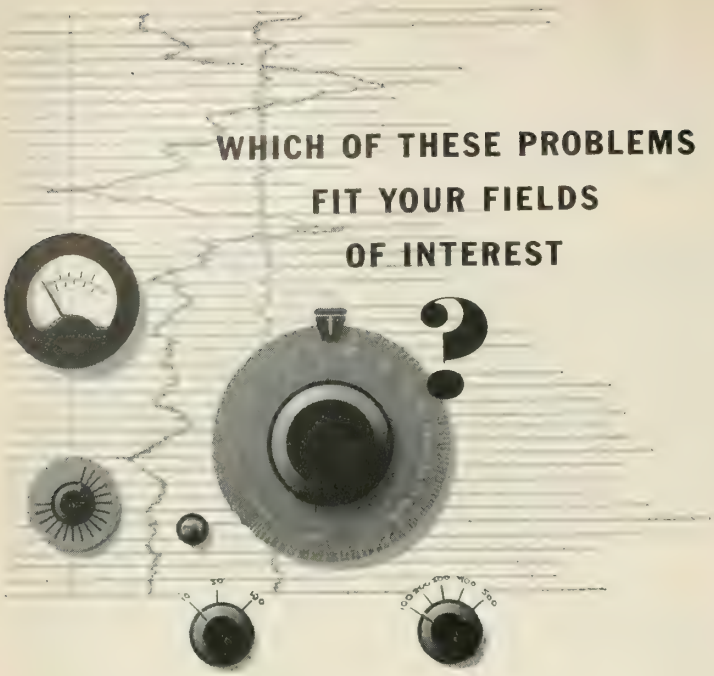
In its missile system and jet propulsion undertakings, the Laboratory maintains a broad technical responsibility, from basic research to prototype engineering. By virtue of this and the integrated nature of the JPL technical staff, each individual is drawn into close contact with the general field to which his specialized technical abilities contribute the most.

If you are interested in knowing more about our work and the specific employment opportunities now open, please send us an outline of your technical background and experience.

CALTECH jpl **JET PROPULSION LABORATORY**

A DIVISION OF CALIFORNIA INSTITUTE OF TECHNOLOGY

PASADENA, CALIFORNIA



Bell Aircraft is continuing its pioneering in the fields of research aircraft and weapon systems. Testing techniques and equipment must be developed which will establish design acceptibility of radical new developments. The range of testing covers all prototype weapon systems and aircraft elements. Here are just a few problems typical of those we are now encountering.

1. Given the conditions for thrust chamber operation of a total propellant weight flow of 20 lbs. per second and a mixture ratio of 5 to give a chamber pressure of 600 psia; what new tank pressures would be required for a mixure ratio of 4 if the original tank pressures had been 1,000 psia on the oxidizer tank, and 900 on the fuel tank.

2. Develop test planning and group testing of varied projects involving radical airplane concepts and electronic systems for flight control and navigation.

3. In the design of a radar range calibrator test set, a digital counter with a frequency division of 627 is required. The circuit to be designed must operate properly under the following variable conditions:

1) Plate supply voltage is 300± 100 volts DC.
2) Filament supply voltage is 6.3± 2 volts AC.
3) Temperature range +100° C to -40° C.
4) Shock up to 50 g's.
5) Frequency range (counter input) up to 5,000 P.R.F.

If your qualifications place you in a position to help solve these challenging problems...or if you are now limited in the scope of your opportunity and would like to participate in any of Bell's widely diversified activities in other fields, write today: Manager, Engineering Personnel, Department U-1 **BELL AIRCRAFT CORPORATION,** P. O. Box One, Buffalo 5, N. Y.

BELL Aircraft corp.

BUFFALO N.Y.

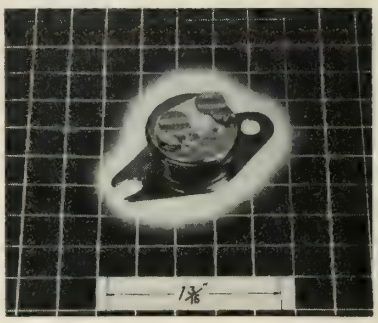


is a 4098 Triad octal plug. Magnetic Research Corp., 200 Center St., El Segundo, Calif.

Circle No. 225 on Subscriber Service Card

PRECISION THERMOSTAT

Hermetically sealed, snap-acting thermostats developed for aircraft and missile installation can be preset at factory over range from —65° to 400°F and are then non-adjustable. Electrical ratings extend up to 7 amps resistive, 30 volts a-c/d-c; 6 amps resistive, 125 volts a-c; 3 amps resistive, 250 volts a-c depending on life expectancy.



Thermostat weight is 4 grams and design conforms to Spec. MIL-E-5272A. Insulation resistance is 1,250 volts a-c, 60 cycles for one minute. Overall height of a right-angle terminal model is 0.50 in. maximum including bracket, although flattened or pierced terminal types are also available.

Metals & Controls Corp., Spencer Thermostat Div., Attleboro, Mass.

Circle No. 207 on Subscriber Service Card

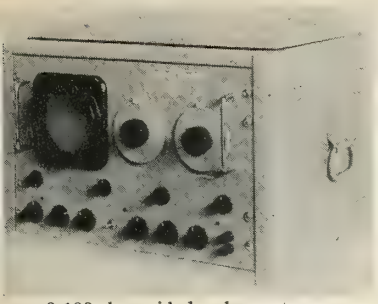
SPACE SUIT



New full-pressure space suit developed for Navy Bureau of Aeronautics is said to be the lightest yet produced and substitutes specially designed shoulder and upper-arm bellows for metal bearings used previously. Although most details are classified, the new high-altitude garment is said to permit pilots to sit, stand and walk freely. Arrowhead Rubber Co., 2350 Curry St., Long Beach, Calif.

Circle No. 202 on Subscriber Service Card

SPECTRUM ANALYZER



0-100 kc wide-band spectrum analyzer is available that will give an instantaneous fuorier analysis of noise, vibration and harmonics in applications of telemetering, aircraft tests and for the filter, acoustic and medical fields.

Special features are automatic optimum resolution, bandpass input filter, continuously variable center frequency and sweep width controls. A flat 5-inch cathode ray tube is used with a camera mount bezel.

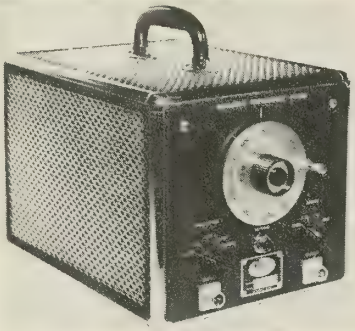
Input range is 500 microvolt to 500 volts full scale. Probescope Co., 44-05 30th Ave., Long Island City, N. Y.

Circle No. 218 on Subscriber Service Card

VARIABLE FREQUENCY FILTER

A variable filter designed for use with vibration analyzers made by the same firm provides for measurement of amplitude and phase of vibration frequencies. The Model 1065 Variable filter permits tuning or scanning of the vibration spectrum over frequencies up to 30,000 cpm with a rated accuracy of 5%, and within 10% from 30,000 to 300,000 cpm.

The unit operates from 110 volts, 60 cycles, single-phase power. Bandwidth is ±5% of the nominal frequency to the 3 db-down points. The Model 1065 filter is inserted between an IRD velocity pickup and the vibration analyzer which is being used. International Research and Development Corp., Columbus, Ohio.



Circle No. 224 on Subscriber Service Card

HIGH TEMPERATURE RIVET

New stainless steel rivet for aircraft and missile structures requiring high strength at high temperatures has an 85,000 psi shear strength at 800°F. Room temperature shear strength is more than 100,000 psi.

Designated the Cherry "600," the new rivet uses a stem and sleeve of A-286 stainless steel, heat-treated and aged for optimum strength and corrosion resistance.

Write: Townsend Co., Dept. M/R, Box 2157-Z, Santa Ana, Calif.

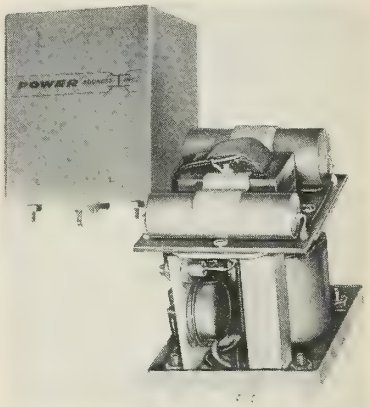
Circle No. 204 on Subscriber Service Card

MISSILE POWER SUPPLIES

Four new all semiconductor dc-dc converters have been announced for use as missile beacon power supplies and other mobile applications. Units are available with inputs of 12 and 28 volts dc and filtered dc outputs of 325 volts at both 100 and 200 milliamperes.

Units are supplied in hermetically sealed packages measuring 3 1/16 x 3 3/16 x 2 5/8 inches. The supplies use two power transistors in an oscillator to interrupt the dc input.

Silicon power diodes and special capacitors are used in the rectifier circuit. Regulation is rated as 20% on standard units, and 0.5% regulation with special input-output voltages can be provided on a custom basis. Power Sources, Inc., 6 Schouler Court, Arlington, Mass.



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ALREADY SOLVING PROBLEMS IN THE AGE OF ASTRONAUTICS

Born in the "fringe area" of industrial lubrication, MOLYKOTE Lubricants have grown under the pressure of the toughest problems industry has to offer. Extreme pressures and temperatures: unusual environments, high starting friction, resistance to centrifugal force, obstinate fretting . . . MOLYKOTE has solved many. Truly, MOLYKOTE has been called "Industry's Most Versatile Lubricant".

To the Age of Astronautics MOLYKOTE brings ● THERMAL STABILITY, retaining its lubricity from -300°F to 700°F in air. 2000°F in vacuum ● CHEMICAL STABILITY, resists all but a few strong acids ● A NATURAL AFFINITY for adherence to metal, rubber, plastics, etc. ● A FAVORABLE LUBRICANT structure. Low friction sliding surfaces are an integral part of the molecule ● RESISTS PRESSURES beyond the yield point of any metal.

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THE ALPHA MOLYKOTE CORP.

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This comprehensive, elaborately illustrated booklet provides practical information on the use of the famous A. C. M. I. Borescope in various industries, for the inspection of interior areas or surfaces not otherwise visible—together with full data on the types of Borescope available, and on their care and maintenance. Have you received your copy?

To *American Cystoscope Makers, Inc.*

1241 LAFAYETTE AVENUE NEW YORK 59, N. Y.

Gentlemen: Please send me without obligation a copy of your booklet on Borescopes.

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Honeywell's infra red devices can

Detect lighted cigarette over half mile away

IT'S PRETTY amazing—when you realize the average cigarette radiates only two watts. This gives some idea of the sensitivity—and range—of the Honeywell infra red systems.

And from there it doesn't take a great deal of imagination to realize the effectiveness of military equipment using these detectors.

Developed after years of research, economical, non-jammable Honeywell systems are now being produced for use on classified weapons.

Solution of the infra red problems adds one more important field to Honeywell ordnance division's array of weapons systems. And it puts us in an excellent position to take on new developments.

Experts in our ordnance division can draw upon a pool of over 25,000 skilled men and women in research, engineering, design and development, production and field service. And standing behind them is over seventy years of engineering and production know-how.

If you require development work in the areas of missile equipment, fuzing, fire control, underwater ordnance or special products, Honeywell ordnance division would welcome your inquiry. Phone, wire or write to Honeywell Ordnance Division, Dept. MI-1-09, Hopkins, Minnesota.

Honeywell Customized Weapons Systems

Warheads; Infra red systems and components; Test, check-out and training devices; Transistorized converters, inverters, rectifiers; Thermal batteries; Mechanical, electro-mechanical and electronic fuzing; Sonar detection systems; Ground-based fire control systems; Stabilized platforms.

MINNEAPOLIS **Honeywell**

H HONEYWELL **ORDNANCE DIVISION**

missile literature

HIGH CURRENT RECTIFIERS. An 11-page brochure, No. ECG-148A, of application notes and graphical data on General Electric's 4JA60 series of small high current silicon rectifiers is available. The new units handle up to 10 kilowatts in a three phase circuit. Write: General Electric Co., Dept. M/R, Semiconductor Products Dept., Electronics Park, Syracuse, N. Y.

MAGNETIC SHIELDING. A 33-page brochure entitled Data Sheets 101 (1957), describes construction features, performance characteristics and typical applications of non-shock sensitive, non-retentive Fernetic and Co-Netic magnetic shielding material. There are 14 pages of illustrations and 5 pages of graphical data. Write: Magnetic Shield Division, Perfection Mica Co., Dept. M/R, 20 N. Wacker Drive, Chicago 6, Ill.

TAPE RECORDER. A 24-page bulletin No. 1561B describes complete characteristics of a new magnetic tape recording and playback system for handling stress, pressure, temperature and vibration data. Detailed photographs of different parts of the Consolidated DataTape system are also provided. Write: Consolidated Electrodynamics Corp., Dept. M/R, 300 North Sierra Madre Villa, Pasadena, Calif.

ELECTRONIC COMPONENTS. A 15-page catalog of AN connectors, RF connectors, Rack and Panel connectors and RG-/U coaxial cables stocked by Amphenol distributors for same-day delivery. Catalog IEC-2. Write: Amphenol Electronics Corp., Dept. M/R, 1830 South 54th Ave., Chicago 50, Ill.

TECHNICAL LITERATURE

TUBE MANUAL. A new edition of the Radio Corp. of America receiving tube manual, RC-18, has been announced. Technical data on 575 receiving tubes and cathode ray tubes is included. (Price $.75). Write: Commercial Engineering, Tube Division, Radio Corp. of America, Dept. M/R, Harrison, N. J.

TEST EQUIPMENT DATA. A comprehensive compilation of descriptive data on more than 1300 electronic test equipments has been published to fill a need in the electronics industry for a handy time-saving reference file of information in this field. Information comes in five volumes of hard cover binders. Periodic additions and revisions will be published. The complete set, including revisions costs $170.00. Write: Carl L. Frederick & Associates, Dept. M/R, 4630 Montgomery Ave., Bethesda 14, Md.

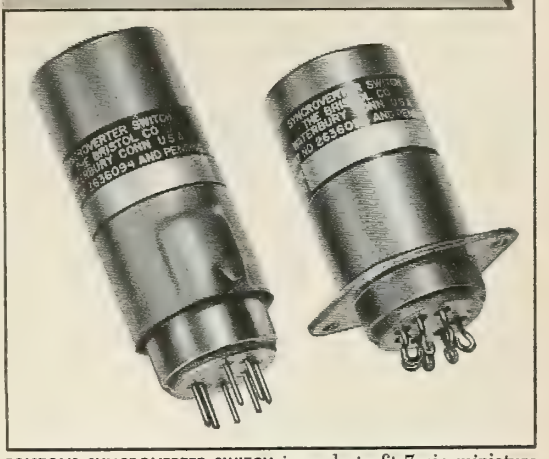
STORAGE BATTERIES. Yardney Electric Corporation, 40-50 Leonard St., N.Y. 13, N.Y. announces publication of a new brochure on its line of SILVERCEL* (silver-zinc) and SILCAD* (silver-cadmium) rechargeable storage batteries. The outstanding features of Yardney cells are outlined in an attractive three-color folder. These advantages include light weight, small size, flat voltage characteristics and high current output. Copies of the new brochure will be mailed free on request by the Yardney Electric Corp. Ask for "Compact Power by Yardney."

RECORDING CAMERAS. Multiple-purpose precision data recording cameras are the subject of an eight page, illustrated brochure offered by Flight Research, Inc., Richmond, Va. Small and lightweight, the MULTIDATA cameras permit automatic, synchronized motion picture or single frame operation. Full operating specifications and details of construction are given for both the MOD III 16mm and MOD IV-C 35mm MULTIDATA cameras. Complete information is contained in the bulletin. Write for a copy to Flight Research, Inc., Post Office Box 1-F, Richmond, 1, Va.

MINIATURIZED GEAR BOXES. A revised four-page, two-color illustrated brochure, number SW-1, describes and illustrates Southwestern's miniaturized gear boxes, miniaturized vibration-resistant pressure switches, and light-weight, compact screwjack actuators. Southwestern Industries gear boxes are designed for electronic and instrument applications, servo mechanisms, computers, small actuators and electronic components. Write: Southwestern Industries Inc., 5880 Centinela Ave., Los Angeles, Calif.

SERVO CONTROL VALVES. Cook Research Laboratories Division of Cook Electric Company, Chicago 14, Ill., has released Volume 3, No. 2 of the Cook Technical Review. This issue of 28 pages deals with electrohydraulic servo valves. Part I presents basic information relative to the types and characteristics of high response servo control valves. The subsequent part describes the various types of valves which are commercially available and discusses the selection of electrohydraulic servo valves and their system application. Bernard A. Johnson, Project Engineer; Lee D. Schmid, Senior Engineer; and Jay Warshawsky, Technical Director, Automatic Control Systems Section, all of Cook Research Laboratories, are the authors of this issue of The Cook Technical Review. The price of this issue of the Cook Technical Review is $1.00 per copy in U.S. and Canada ($1.25 in other countries).

WHAT'S NEW AT BRISTOL...



BRISTOL'S SYNCROVERTER SWITCH is made to fit 7-pin miniature tube socket *(left)* or ¾-in. diameter chassis hole *(right)*. Covered by patents.

"Most reliable miniature chopper we've tested!"

That's the playback we're getting from electronic engineers all over the country on the high-performance Bristol Syncroverter® switch. One engineer writes:

"In seven years of experience in applying similar devices, we have not found a chopper as reliable . . . after our tests no deterioration in performance was found, and we believe there is no equivalent meeting our requirements."

Another electronics engineer comments on his life-tests:

"The switch has passed the 1000-hour mark without the slightest degradation of the wave form."

The Syncroverter switch has a normal *operating life of thousands of hours*. It's a polarized, SPDT, non-resonant switch that provides break-before-make action in synchronism with a sine or square-wave driving current anywhere in the frequency range of 0 to 2000 cps. In addition to reliability and long life, it's noted for light weight (only 1.7 ounces) low noise level, and clean wave form.

Write today for free bulletin on the high-performance Syncroverter switch. The Bristol Company, 150 Bristol Road, Waterbury 20, Conn. 6.10

TYPICAL OPERATION

	400 cps	500 cps
Coil voltage	6.3V sine, square, pulse wave	6.3V sine, square, pulse wave
Coil current	55 milliamperes	45 milliamperes
Coil resistance	85 ohms	85 ohms
*Phase lag	55° ±10°	65° ±10°
*Dissymmetry	less than 4%	less than 4%
Temperature	—55°C to 100°C	—55°C to 100°C
*Switching time	15° ±5°	15° ±5°

Mounting—Any position—fits 7-pin miniature socket

These characteristics based on sine wave excitation

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Universal DC Meter

This new microvolt-ammeter-amplifier will measure as little as 10 μv or 10 $\mu\mu$a with accuracy. It may also be used as a DC amplifier with up to 80 db gain and only 10 μv drift. A zero-center mirrored scale provides instant polarity indication. Utilization of Kay Lab's chopper stabilized circuit provides versatility, accuracy, and stability that is unobtainable with conventional VTVM's. The Model 203 is the ideal general purpose laboratory meter, production test set, or null meter.

SPECIFICATIONS

- 100 μv to 1000 v fs
- 100 μa to 100 ma fs
- 25 ranges
- 100 megohms input
- 80 db gain as amplifier
- 10 μv equivalent input drift
- 1 volt output
- Price $550.

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Write for literature or demonstration

KAY LAB

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people



Well-known general buries a smile as world's top ballistic missile expert says: "I read in LIFE magazine that we are supposed to have fired a missile 3,000 miles . . ." Some of those at the head table for the Honors Night dinner at the recent annual meeting of the American Rocket Society in New York included (left to right): REAR ADM. JAMES S. RUSSELL, Chief, Bureau of Aeronautics; MRS. JAMES H. WYLD, retiring ARS President, NOAH DAVIS; ABMA Development Director, WERNHER VON BRAUN; ABMA Chief, MAJ. GEN. JOHN B. MEDARIS; CMDR. ROBERT M. TRUAX, USN, AF WDD; MRS. ROBERT H. GODDARD.



Maybe it was the hour, or maybe it was Defense Secretary Wilson's November memorandum that joined well-known science writer WILLY LEY and Boeing engineer NORMAN BAKER in deep contemplation.



Eager beaver KURT R. STEHLING, propulsion chief, NRL's Project Vanguard, listened.



DR. S. FRED SINGER, Professor, Maryland University Physics Department, had a point.



The points, in fact, that were made were many and ranged far into the early morning hours.



Rocket pioneer and former ARS President G. EDWARD PENDRAY describes a fundamental principle.



From Peenemunde to Redstone—Former German professor HERMANN OBERTH, father of space flight, now special consultant to VON BRAUN at ABMA.



Making the round of hospitality suites was a tough circuit; playing host was tougher.



Curtiss-Wright's G. S. WING seems to have doubts as to where it all will end.



And two just couldn't take it any longer.

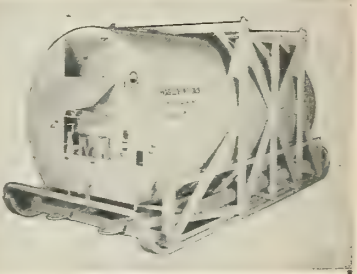
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people

Peder W. Larsen, formerly Senior Military Officer at the Royal Aircraft Establishment at Farnborough, England, where he was responsible for the development program of Army guided missiles, has been appointed manager of government projects of PSC Applied Research Ltd.

Bell Aircraft Corporation's new Aircraft Division announces four appointments: **John W. Rane, Jr.,** director of engineering and sales; **George D. Ray,** chief engineer; **Stanley W. Smith,** chief project engineer; **John J. Weisbeck, Jr.,** contracts manager.

Eduard Baruch, president of Heli-Coil Corporation, a subsidiary of Topp Industries, Inc., has been elected a vice president and director of the parent firm.

H. C. Riggs has been named coordinator of missile applications engineering by the Exide Industrial Division of The Electric Storage Battery Co., Philadelphia.



KING

Dr. Donald D. King, formerly director of the Radiation Laboratory at Johns Hopkins University, was elected vice president-research for Electronics Communications, Inc., a subsidiary of Air Associates, Inc.

Alden R. Ludlow, Jr., has been appointed director of sales for U.S. Industrial Chemicals Co., Division of National Distillers Products Corp.

Roy S. Fisher was elected vice president and named director of sales for National Vulcanized Fibre Co.

John S. Anderson, president of Aeronautical Radio, Inc., has been reelected to a two-year term as vice chairman of the Radio Technical Commission for Aeronautics.

C. Charles Miesse, a specialist in liquid propellant engines, formerly with Aerojet-General Corp., has been named supervisor of the newly created combustion section at Armour Research Foundation of Illinois Institute of Technology, Chicago, supervising activities in area of combustion, jet engines, liquid rocket engines and gas turbines.

David D. Stone has been appointed vice president in charge of sales and customer relations for Wyle Laboratories, El Segundo, Calif.

Robert L. Clark has been appointed to head Ryan Aeronautical Co.'s Manufacturing Division.

Charles E. Miller has been named head of engineering services for the Pacific Division, Bendix Aviation Corp. **William H. Chester** and **Charles W. Thomas** have been appointed asst. supervisors of the telemetry engineering section of the division.

Dr. William B. McLean, technical director of the Naval Ordnance Test Station, has received a $25,000 cash award for his role in the development of the Navy's *Sidewinder* air-to-air missile. Decorations and citations were awarded the following men, who developed the first guided missile, the TDR-1, launched in wartime against the enemy: **Commodore Oscar Smith** (Ret.), **Capt. Robert Jones** (Ret.), **RADM D. S. Fahrney** (Ret.), **LCDR Fred Wallace, Lt. William Bowlin, LCDR John Burrell, LCDR William Bailey, Capt. S. E. Jones,** and **Capt. G. E. Merrill.**

John N. Kerr, former chief of associated projects at Northrop Aircraft, Inc., has been appointed vice president of Horkey Associates.



BAILEY

John T. Bailey has been named quality control director for Bell Aircraft Corp.'s Weapon Systems Division; **Raymond C. Sears** was named director of quality control for Aircraft Division. New assignments in the Rockets Division, a unit of the Weapons Systems Division, are **Floyd H. Walters,** director of manufacturing; **R. Dewey Rinehart,** director of engineering; **Harry A. Ferullo,** director of programs; **Stephen D. Krull,** director of tests; **Joseph R. Piselli,** manager of customer relations and sales; **Melvin J. Blessing,** manager of contract administration.

Phillip Movitz, staff asst. to the division general manager, Grand Rapids Division of Lear, Inc., has been promoted to quality control manager. **J. C. Owen** has been named manager of the advanced engineering department of the division.

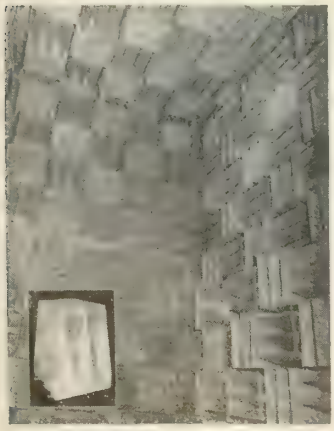
R. J. Sullivan has been named director of quality control and **Conrad Hohmann,** asst. chief engineer-special airborne devices, for Vickers Inc. **Mr. Sullivan** will be responsible for coordination of quality control at Detroit, Omaha, Joplin (Mo.) and Jackson (Miss.) divisions.



SHAW

George B. Shaw, vice president-procurement for The Martin Co., has been named president of Martin International, a new subsidiary company which will develop world markets for nuclear powered electrical generating systems.

Dr. Adolph K. Thiel has been appointed assistant program director for the *Thor* intermediate range ballistic missile program.



Inset shows design and construction of typical AN-ECK-OIC® WEDGE

Engineering Laboratory Anechoic Chamber installation Pratt & Whitney Aircraft East Hartford, Connecticut

AN-ECK-OIC® WEDGES

Another AN-ECK-OIC® WEDGE installation

Anechoic Chambers are recognized as valuable facilities for analyzing noise sources in automotive and aircraft engines, components, auxiliary machines, electric and audio equipment.

Recent Anechoic Chamber installations have been constructed for General Electric Co., Pittsfield, Mass., The National Bureau of Standards, Washington, D. C.

In many of the Anechoic Chambers in the United States, AN-ECK-OIC® Wedge units made by THE ECKEL CORPORATION provide the near perfect sound absorption.

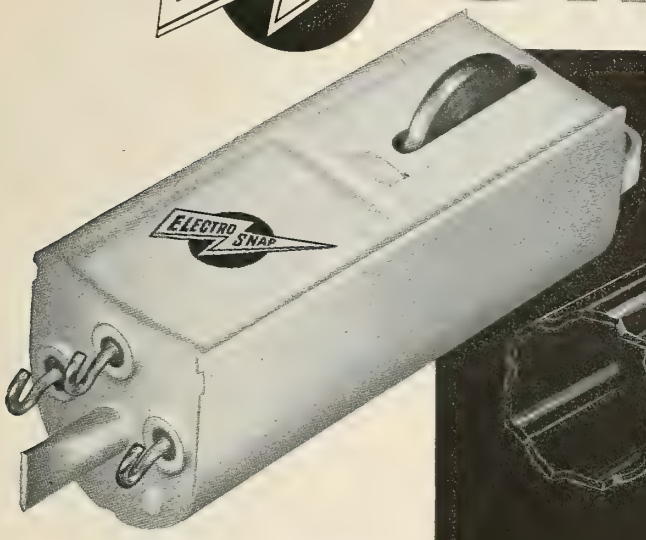
For the silencing of Engine Test Cells, Firing Ranges, noisy machines and equipment consider the use of ECKOUSTIC® Sound Control Panels —product of THE ECKEL CORPORATION.

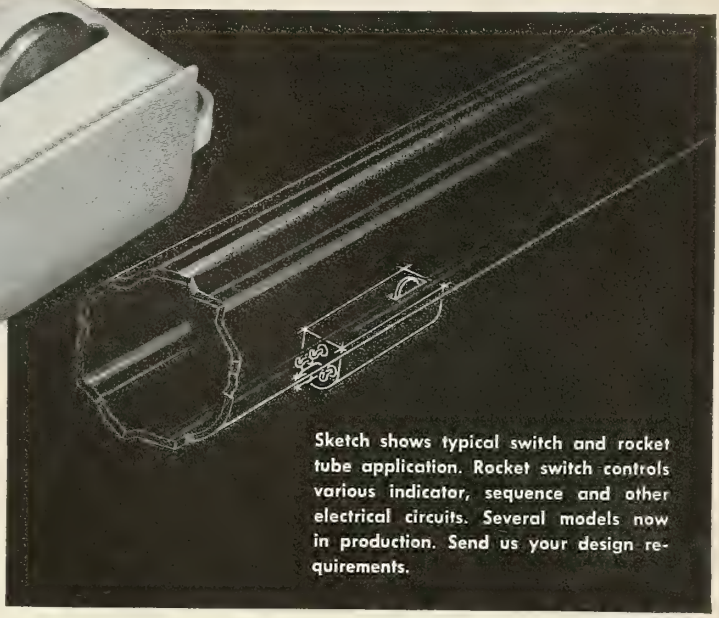
The Eckel Corporation Engineering and Installation organization can be helpful to you in solving your sound laboratory problems.

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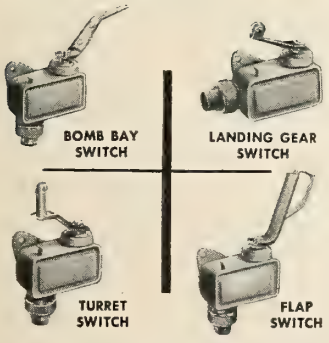
new ELECTRO SNAP ROCKET SAFETY SWITCH





Sketch shows typical switch and rocket tube application. Rocket switch controls various indicator, sequence and other electrical circuits. Several models now in production. Send us your design requirements.

...from the makers of the leading line of HERMETICALLY SEALED LIMIT SWITCHES



Electro-Snap has developed a complete line of hermetically sealed limit switches to bring the ultimate in environment-free switching to aircraft control circuits. With a record of dependability totaling millions of hours, Electro-Snap Hermetically-Sealed Switches have been used as original equipment by major aircraft producers—on standard and experimental aircraft for both commercial and military use. They are also being widely used for retro-fitting, to modernize existing control circuits for the more exacting demands imposed on today's aircraft. If aircraft switching is your responsibility, you should know about this modern line of switches for modern aircraft. Write for specifications.

To meet modern aircraft requirements, Electro-Snap has developed and perfected this, the first truly hermetically sealed rocket switch. Because both the basic switch and the operating mechanism are sealed in an inert gas, the switch is unaffected by extreme heat, or cold, humidity, water, oil or temperature cycling. Tipping action of the actuator prevents jamming by ice. Completely environment-free, the dependability of the switch and its operating action have been thoroughly proved on today's newest fighter aircraft.

IMPORTANT CHARACTERISTICS

Contact Arrangement ..... SPDT, 1 circuit

Capacity.....4 amps. resistive, 2.5 amps. inductive at 30v DC.

Electrical and Mechanical Life.....150,000 operations min.

Vibration and shock resistance.....Excellent

Full information is available on request. Write for Data Sheet RY-1.

ELECTRO-SNAP SWITCH & MFG. CO.

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We will meet your design requirements—send us your prints

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Labor Dept. Finds Training Lack

The aircraft and missile industry is neglecting apprentice training in a large majority of its major plants and is generally falling short of its goal of meeting skilled manpower needs, according to the Dept. of Labor.

Results of a recent Labor survey show that apprenticeship training is being neglected entirely in 99 out of 143 plants employing more than 400,000 persons each. Only about one-third of the facilities surveyed were found to have some kind of junior training projects under way.

Labor's Bureau of Apprenticeship found that aircraft and missile firms not participating in apprentice programs are relying on short-term training, upgrading, recruitment from other plants, and other haphazard methods for skilled workers. It noted that a few plants are doing excellent work in training skilled craftsmen, but that they are too few to carry the training responsibility for the industry.

The Labor report states further that the chronic skilled-manpower shortages in the industry over the past few years point up the need for developing adequate training programs in many plants not presently training workers to meet their skilled manpower needs.

Full text of the Labor study, entitled *Training in the Aircraft Industry*, is available free from the Publications Branch, Bureau of Training and Apprenticeship, Dept. of Labor, Washington 25.

Douglas Employes Get Pay Raise

More than 7,000 salaried employes at the five divisions of Douglas Aircraft Co. were scheduled to receive a pay increase ranging from 4% to 7% effective January 7. Average rate of increase was placed at more than 5%.

The new wage hike effects all salaried employes except those represented by the Southern California Professional Engineering Assn. Similar upward adjustments are scheduled by the company for some 3,400 represented by SCPEA upon approval of the pay formula by the union membership.

No Seniority Loss In Missile Move

Transfer of employes in Lockheed Aircraft's Missile Systems Div. from Van Nuys to the San Francisco Bay area will involve no loss in seniority. Company has signed a new wage agreement with Local 508, International Assn. of Machinists.

Republic Launches EngineeringTraining

Republic Aviation Corp. this month will inaugurate a non-credit, college-level training program to be conducted on company time for its engineering personnel. A series of 15-week courses taught by Republic engineers will extend from drafting room mathematics to stress analysis. The company expects enrollment eventually will reach 1,500.

The new program is designed to ease the shortage of trained technicians by upgrading the qualifications of personnel now employed, according to Republic president Mundy I. Peale. Classes begin on January 7.

Two Missile Firms Plan Denver Plants

Two missile accessory firms, both subcontractors to The Martin Co. in its *Titan* ICBM project, are planning to open new facilities near Martin in Denver. One is Associated Missile Products Corp. located at Pomona, Calif. and the other Hallamore Electronics Co. of Anaheim, Calif. Latter is a division of Siegler Corp. of Chicago, Illinois.

Associated Missiles will locate a field office at 3550 So. Inca St. and

Senior Research Scientist

for Fundamental Studies of

Interior Ballistics

of solid propellant

rocket engines

A challenging position is now open for a man of broad, fundamental background capable of original experimental and theoretical studies, who desires to contribute significantly to the nation's missile program.

The range of individual initiative is practically unlimited; the climate, beauty and living conditions of historic Sacramento completely satisfying.

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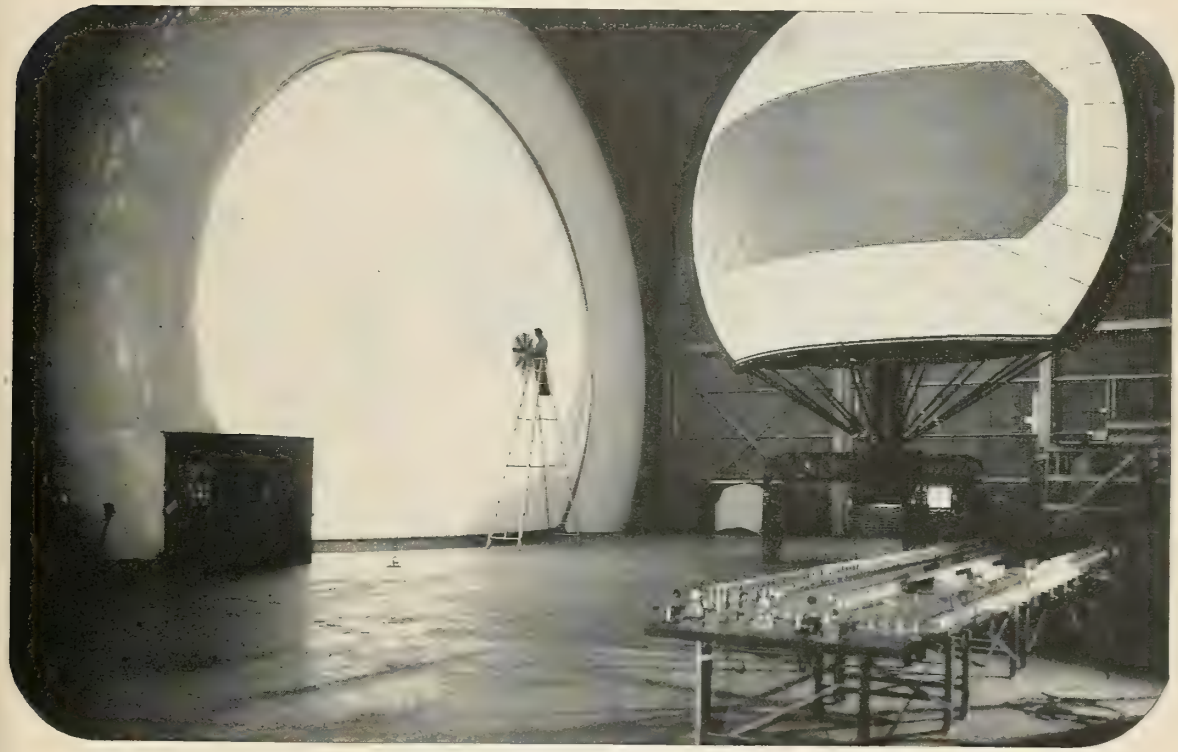
A Subsidiary of The General Tire & Rubber Company — THE GENERAL TIRE — PLANTS AT AZUSA AND NEAR SACRAMENTO, CALIFORNIA

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Another first!

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PARABALLOON *Acclaimed "A Major Breakthrough for Air Defense"*



The Paraballoon is a ground radar antenna that can be inflated or deflated like a balloon, folded and packed into air lift containers for tactical operations.

Westinghouse engineers at the Electronics Division in Baltimore developed the Paraballoon for the Rome Air Development Center . . . and every conventional radar antenna became obsolete over night! *Aviation Week* headlined the news with a cover story in their October 22nd issue . . . and *Life Magazine* featured it on November 5th.

The Paraballoon is a radically different type of ground radar antenna. Unlike the conventional antenna which weighs over 10,000 pounds, the Paraballoon weighs only 1,700 pounds. With it, a trained crew of 20 men can set up a complete radar station in two hours. Major General Stuart P. Wright, Commander of Rome Air Development Center, was quoted in *Aviation Week* as saying that the Paraballoon is "A major breakthrough for our air defense."

This is just one of many firsts for the engineers at Westinghouse-Baltimore. Inheritors of the Westinghouse pioneering tradition, and leaders in electronics developments, the engineers at Westinghouse-Baltimore are engaged in vital defense projects far beyond the "state of the art." Here, the engineer has unlimited opportunities—in a company where engineers are respected and rewarded for their contributions.

Investigate the opportunities open to you at Westinghouse-Baltimore.

Current Openings at Westinghouse-Baltimore

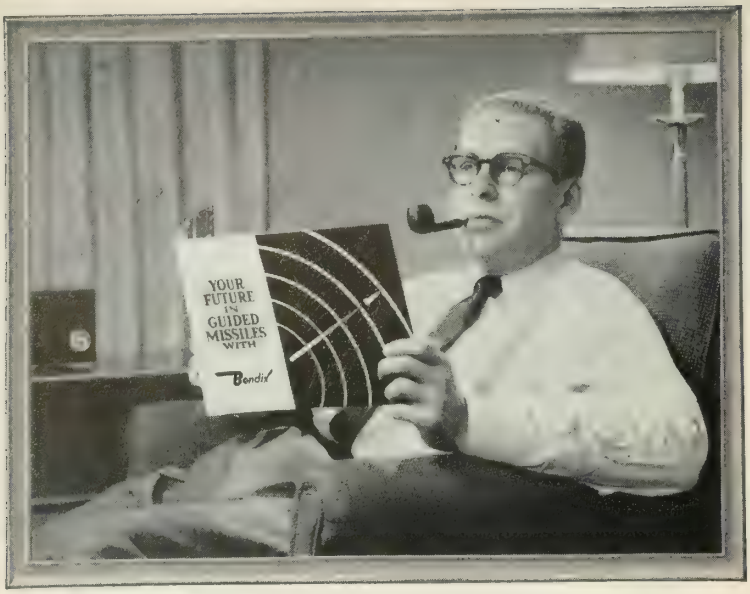
CIRCUITRY	ANALOG COMPUTER DESIGN
MICROWAVES	VIBRATION
SERVOMECHANISMS	RADAR DESIGN
MAGNETIC AMPLIFIERS	METALLURGY
DIGITAL COMPUTER DESIGN & APPLICATION	FIELD ENGINEERING
FIRE CONTROL SYSTEMS	INFRARED TECHNIQUES
OPTICS	ANTENNAS
COMMUNICATIONS	TECHNICAL WRITING
PACKAGING	TEST EQUIPMENT
TRANSFORMERS	HYDRAULICS
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WESTINGHOUSE-BALTIMORE



Picture of a young man

Planning a Successful Future!

Success doesn't just happen to a company or to an individual. Success comes as a result of clear thinking and long-range planning.

And that is just what the young engineer in the picture is doing. He is studying the many possibilities of a career in guided missiles.

The book he is reading is entitled "Your Future in Guided Missiles with Bendix". It is one of the most complete guides to job opportunities in the guided missile field. It also contains a detailed background of the functions of the various engineering groups such as systems analysis, guidance, telemetering, steering intelligence, component evaluation, missile testing, environmental testing, test equipment design, reliability, propulsion and other important engineering operations.

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expects to maintain about 60 to 65 engineers at the new facility. It will be headed by William Entrickin, former general manager of AMF's Micro-Pak Division in Colorado Springs.

Hallamore plans to open its Denver office at 1301 W. Third Ave. later this month and expects to expand by late 1957 to a staff of between 500 and 600 employes and payroll of about $300,000.

Pentagon has clamped a top secret cloak on the activities of both companies in the *Titan* project, a positive indication they are both key producers in the vital missile program.

Aircraft, Missiles Top $3 Billion

Air Force and Navy contract awards in October 1956 for aircraft, missiles and drones and related equipment totaled $387 million raising their total obligations for the first quarter of fiscal 1957 to $3,235,000,000.

Of this amount, AF obligated $181 million in October and $2.19 billion for the four months. Navy placed $206 million in orders in October and $1,045,000,000 for the four month period since July first.

Air Force spending, meanwhile, totaled $613 million in October and $2,117,000,000 from July through October whereas Navy figures were $169,000,000 and $580,000,000 respectively. Total spending for both services for the Fiscal 1957 first quarter in aircraft and missile categories amounted to $2,697,000,000.

Aviation Industry No. 1 Employer

The nation's aircraft industry, including an ever-increasing activity in guided missile development and production, became the nation's largest commercial employer in 1956, according to Aircraft Industries Assn.

AIA's year end report placed average industry employment at 800,000, an estimated 50,000 above the automobile industry in second place. It also noted that aircraft and missile workers increased their hourly earnings from an average $2.17 in 1955 to $2.31 by September 1956 with the trend still on the increase at the year end.

AIA also predicted a substantial change in the proportioning of Defense aircraft and missile orders in the future. By 1958, it said, military aircraft and related equipment procurement probably will assume a ratio of 65-to-35 in favor of manned aircraft over missile.

By as early as 1961, however, AIA viewed the possibility this ratio may become 50-50.

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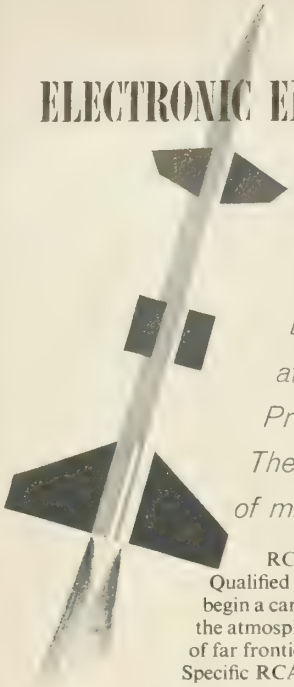
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West Coast Stresses Engineer Shortage

Los Angeles Council of Engineering Societies, acting jointly with the Technical Societies Council and Consulting Engineers Assn. have set aside February 18-22 as Engineering Week in Los Angeles. Its dual purpose will be to focus public attention on the growing shortage of engineers and their importance to the well-being and security of the nation.

General chairman of the activity will be J. Calvin Brown, a past national president of the American Society of Mechanical Engineers. Guest speaker at a banquet February 21 at the Statler Hotel will be Donald W. Douglas, president of Douglas Aircraft Co. Douglas also will be presented an award in recognition of his contributions to engineering and the Southern California aircraft industry.

Aerojet to Expand Plastics Activity

Aerojet-General Corp. has announced plans for major expansion of its structural plastics group within its Solid Engine Division. The program calls for new buildings and equipment to facilitate plastics research, development and manufacturing.

Main areas of activity for the group, headed by E. L. Rucks, will be in the fields of pressure vessels, thermal insulation and missile/rocket components.

Minn-Honeywell Forms New Division

Minneapolis-Honeywell Regulator Co. is combining the operations of its Doelcam Division and Transistor Division into a single organization identified as the Boston Division.

The new M-H unit will have two sections—semiconductor products and instruments—under division v.p. and general mgr. George J. Schwartz.

Employment Up in San Diego Area

Employment by San Diego's four major aircraft and missile manufacturers or subcontractors totaled 50,898 on December 15 marking an increase of 1,550 over November 20.

Convair reported 35,022; Rohr Aircraft Co. 7,148; Ryan Aeronautical 5,928 and Solar Aircraft 2,800. Convair employment increased 1,356 in the preceding two-week period.



RECENT BREAKTHROUGHS IN SUPERSONIC AND HYPERSONIC KNOWLEDGE AND TECHNOLOGY— BASIS OF MAJOR RESEARCH AND DEVELOPMENT ACCELERATION AT REPUBLIC AVIATION

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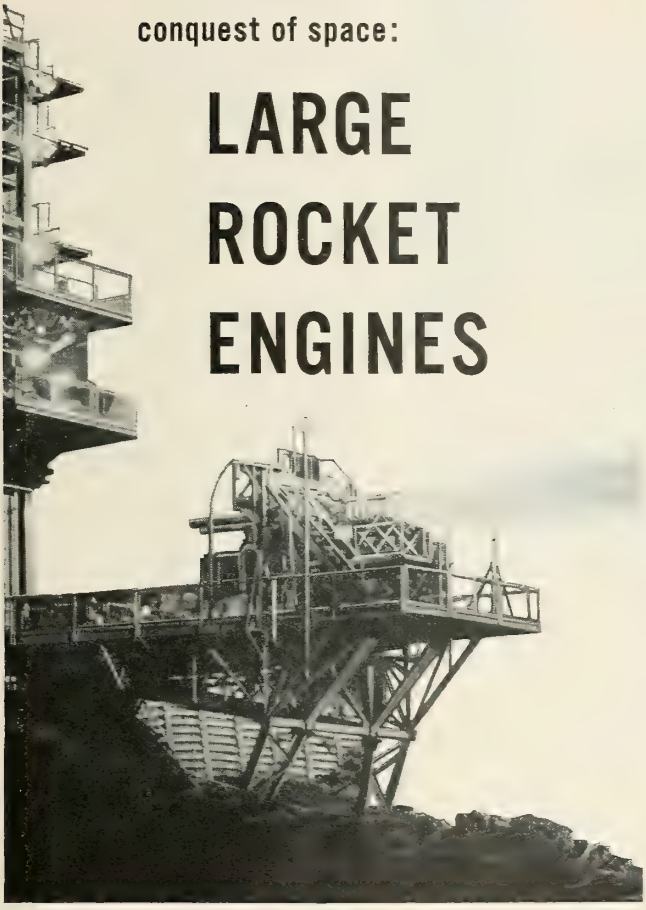
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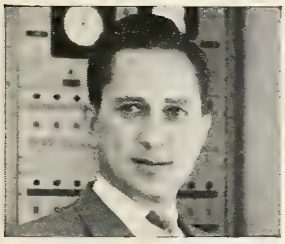
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Design and test for survival in adverse environment is fundamental in producing guided missile components with reliability adequate for modern weapons system requirements. At JPL, a constant search is being conducted for better design and packaging techniques, and for more significant laboratory test methods. Development of the "complex wave" vibration test philosophy, and of apparatus to exploit it, are but two results of this program. In the area of component design, new packaging techniques have been developed, involving control of local internal resonances and nonlinearities, which permit electronic circuits to withstand many times the vibration level which would destroy a conventional package.

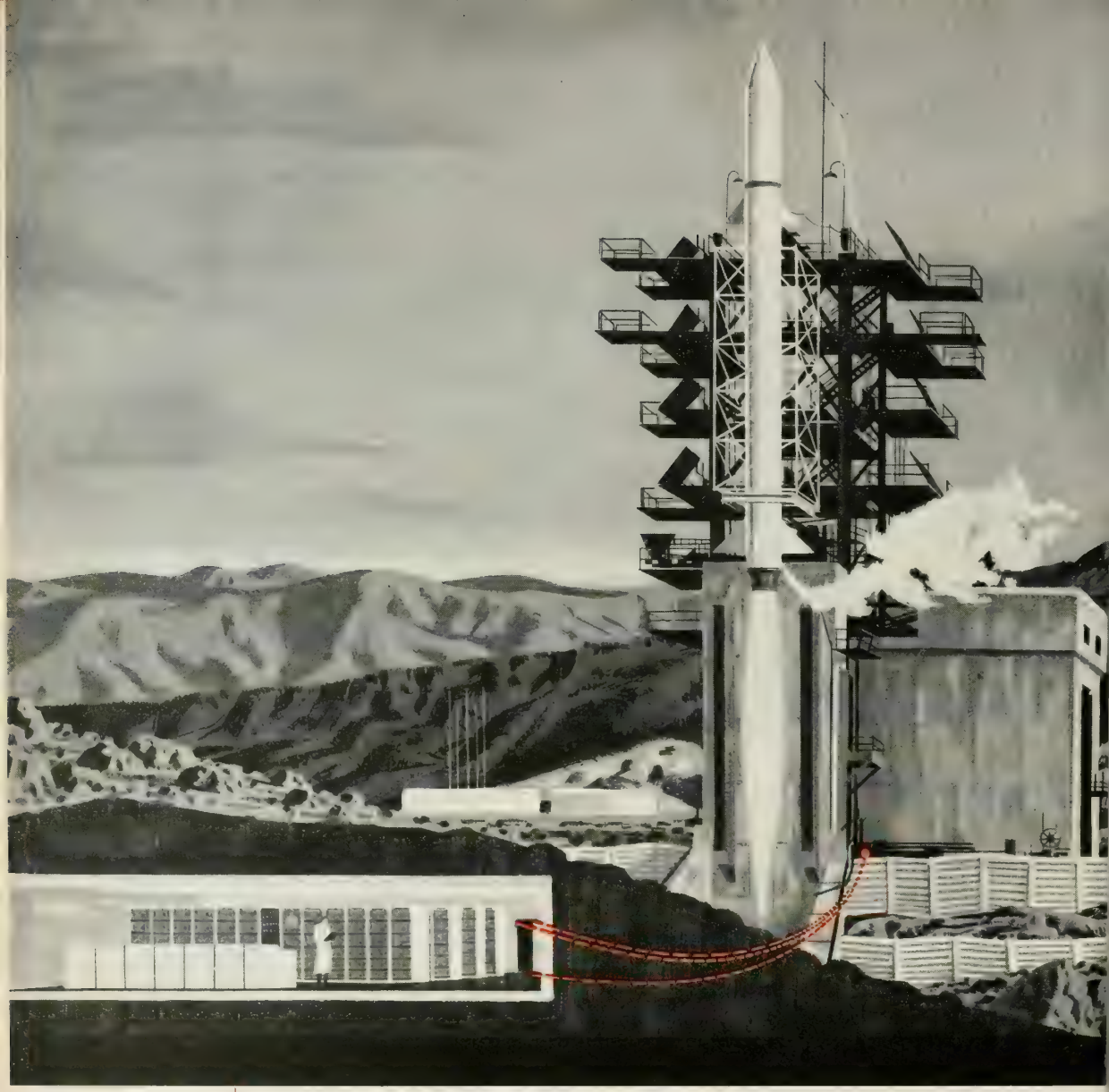
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How Good the Russians?

The editors of this magazine have assembled in this issue more information and data about the Soviet Union's missile activities than have ever been collected in one public place before.

There are many pieces missing as is the case of every enterprise in Russia, especially military. Yet a fair amount is known.

What does it all add up to?

There is no evidence whatever that the Soviet Union has attained (as of now) an over-all superiority or even a measure of equality.

But the evidence is powerful that Russia is striving with all-out effort—and top priority—in the missile field. This is sufficient warning in itself from the greatest imperialist nation in the history of the world.

Three of this country's top military leaders have spoken out recently on the subject of the Red war machine.

Army Secretary Wilber N. Brucker quoted with telling effect Khruschev's pickled comment at a Moscow embassy party, "History is on our side. We will bury you."

Navy Assistant Secretary Garrison Norton urged strongly the continued modernizing of the Navy with missiles if this service is to keep pace with Russian development.

But it was left to General Bernard A. Schriever, Chief of the USAF Western Development Division, to add a reasoned appraisal to his warning of Soviet progress.

General Schriever said the question of whether the U.S. or the U.S.S.R. has the biggest and best ballistic missiles is somewhat like weighing the chances of the participants in an automobile race solely on the basis of their cars instead of considering the training and experience of the drivers, the reliability of their equipment, the support they receive in the pits, and similar factors.

We like that appraisal. The quality of the missile alone is not the decisive factor. As General Schriever said, there must also be know-how and organization for major strategic operations in order to create a real long-range missile capability.

Once ICBMs and IRBMs are added to the inventory of the Strategic Air Command—whose capability and record is unquestioned—"There will be no over-all ballistic missile capability like it in the world."

Such confidence is heartening. But it is warranted just so long as this country keeps missile development in high gear.

WAYNE W. PARRISH

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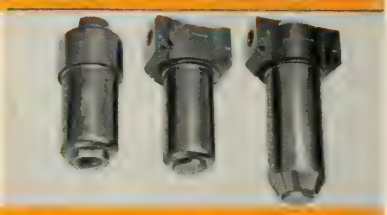


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letters

Radiation Pressure

To the editor:

. . . In a letter "Radiation Pressure" in your December issue, Mr. Norman Blubaugh obviously refers to the Crooke's Radiometer as the revolving element actuated by "light pressure."

It is astonishing that this fallacy of "light pressure" is still fostered; one wonders about the efficacy of physics teaching in this country which does not more clearly demonstrate the absurdity of this premise.

The Crooke's Radiometer is based on the principle of a differential pressure across each vane. The shiny side of each vane is cooler than the black side. Therefore the pressure (in the *partial* vacuum of the bulb) adjacent to the black side is lower than that next to the cool side.

Thus a net force results and pushes the vanes in the direction of the black side. As the radiometer bulb is exhausted to a harder vacuum, the vanes now turn in the opposite direction, with the shiny side turning toward the light. This is caused by the, by now imperfect gas, behaving as discreet particles; these particles when heated by the black side increase their motion and impinge on the black side and transfer their momentum to the black side thus pushing the vanes away from them, that is, i. e., with the shiny side leading.

If the vacuum is reduced to a very low level of pressure then the vanes do not turn at all, no matter how much light impinges upon them. The actual light pressure in micro-micro dynes is immensely less than that required to move the vanes. It is true that a powerful enough light source could produce a motion of the vanes but such a light beam would vaporize the entire radiometer.

As for "sunlight pressure" navigation in space, reflective "sales" of hundreds and thousands of square miles of surface area should be required to propel a vehicle of even a low mass. Furthermore, the light's pressure falling off as the inverse of the distant-squared from the sun further complicates the picture . . .

Kurt R. Stehling
Propulsion Head
Naval Research Laboratory
Washington 25, D. C.

Satellite Camera

To the editor:

. . . After reading Henry Steier's article in the January issue on the satellite tracking cameras, I thought you might be interested to know that the optical systems for the cameras will be one of the most difficult optical production jobs ever attempted. I don't think anything quite like it has been tried before on a production basis.

As you know, the optical design calls for a 31-inch mirror, and three aspheric corrector plates. Until Perkin-Elmer developed economic production methods for aspherics, making such elements of this order were pretty much a hand-made proposition. Generating the aspheric surfaces for these systems will be all the more difficult because of the thickness of the glass, which is so small in proportion to its diameter.

Aspheric surfaces, as you may know, take the form of paraboloids, ellipsoids, hyperboloids or other geometric forms that can only be defined by complex equations. Their advantage to lens design is twofold. First, since an aspheric surface often replaces one or more classical surfaces (spheres or flats), it means lighter weight and smaller lenses. Secondly, aspherics will sometimes correct for aberrations not otherwise correctable, resulting in faster and more precise lens systems . . .

Charles C. Dayton
Public Relations
The Perkin-Elmer Corporation
Norwalk, Conn.

To the editor:

. . . We were very pleased to see from the January issue, on page 64, the description of the Vanguard satellite tracking camera.

You will be interested to learn that the three element Schmidt type objective, consisting of two KzFS-2 and one SK-14 discs of 22″ diameter, was supplied by us and produced by the world-renowned Jena Glass Works of Schott & Gen. in Mainz, West Germany, whom we represent. The optical design was, as noted by you, prepared by Dr. James G. Baker. This glass was found to produce an image with very much reduced secondary spectrum.

We trust that you can make mention of this in your magazine . . .

Murray Yawitz, President
Fish-Schurman Corporation
70 Portman Road
New Rochelle, New York

Name-Change

To the editor:

. . . I should like to call your attention to a mistake in the listing of Subcontractors Guide: "Missile Electronics and Astrionics" which appears in your January issue. On page 79 the name Raymond and Rosen Engineering Products appears. This should be listed as Tele-Dynamics Inc. so as to reflect the name change of our organization which took place on August 1, 1956 . . .

J. M. Millet for
C. W. Kropp
Eastern Regional Manager
Tele-Dynamics Inc.
32nd and Walnut Streets
Philadelphia 4, Pa.

Rocket Producers

To the editor:

I was most interested in your article on the "Mighty Mouse" in the November issue and noticed that two of the Rocket Head manufacturers had been omitted from your list of "Well Done" manufacturing facilities.

Since the current issue has not corrected the situation, I'll have to wave the flag for two of the finest cooperating military producers in the business; namely, Hubeny Brothers, Inc., Roselle, New Jersey, and John E. Mitchell Company, Dallas, Texas . . .

Charles M. Featherstone, Jr.
District Manager
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missiles and rockets vol. 2 no. 2

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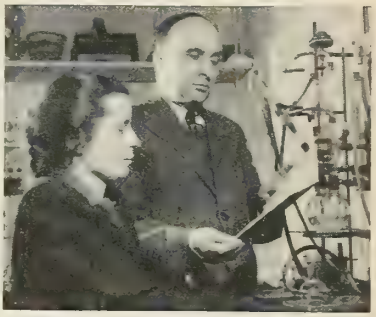
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next issue:

RESEARCH ROCKETS AND MISSILE RELIABILITY

cover picture:



Russia's scientists work intensively toward the goal outlined for them by their military leaders. The Russian scientist has many peculiarities; he or she works long hours, accuracy in their jobs is almost pathetic (see m/r's personal report, page 61). At long last the hero scientific worker might get a medal. This month's cover shows president of USSR Academy of Sciences, Academician Alexander Nesmeyanov, pay visit to rocket lab at the Institute of Chemical Technology, Moscow.

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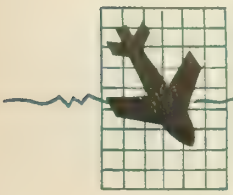
U.S. Army, pp. 22, 50, 54, 55, 87; U.S. Air Force, p. 42; Sovphoto, pp. 17, 38, 49, 71; E. Hull, pp. 43, 61, 62 65, 66, 67, 116; Northrop, p. 21; NAA, p. 23; Temco, p. 23; Lockheed, p. 24; AP, p. 24; Bell. p, 27; Department of Defense, p. 42; W. Geisler, pp. 74, 75; Societe d'Etude, pp. 82, 83; Aerojet, p. 116; ACF, p. 116.



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AFA Jet Age Conference, Sheraton-Park Hotel, Wash., D. C., Feb. 14-15.

Conference on Transistor Circuits, sponsored by IRE, AIEE, Phila., Pa., Feb. 14-15.

Astronautics Symposium, sponsored by Air Force Office of Scientific Research and Convair Division of General Dynamics Corporation, El Cortez Hotel, San Diego, Calif., Feb. 18-20.

Western Joint Computer Conference, sponsored by IRE, AIEE and ACM, Hotel Statler, Los Angeles, Feb. 26-28.

Joint Military-Industrial Guided Missile Electronic Test Instrument Symposium, Redstone Arsenal, Huntsville, Ala., Feb. 26-28.

Nuclear Radiation Effects on Semiconductor Devices and Materials Symposium, sponsored by Department of Defense-R&D, Western Union Bldg., New York City, Feb. 27-28.

MARCH

Nat'l Conference on Aviation Education, Mayflower Hotel, Wash., D. C., Mar. 7-9.

Nuclear Congress & Int'l Atomic Exposition, Convention Hall, Phila., Pa., Mar. 11-15.

IAS Flight Propulsion Mtg. (classified), Cleveland, Ohio, Mar. 14-15.

First Military Automation Exposition, New York Trade Show Bldg., (Richard Rimbach Associates), New York City, Mar. 18-21.

IRE National Convention, Waldorf Astoria Hotel and New York Coliseum, New York City, Mar. 18-21.

151st National Meeting of the American Meteorological Society, University of Chicago, Mar. 19-21.

American Society of Tool Engineers, Silver Anniversary annual meeting, Shamrock Hilton Hotel, Houston, Tex., Mar. 25-27.

10th Western Metal Exposition & Congress, American Society for Metals and others, Ambassador Hotel and Pan-Pacific Auditorium, Los Angeles, Mar. 25-29.

Educational Colloquium on Radiation Effects on Materials, sponsored by ONR and Glenn L. Martin Co., Johns-Hopkins University, Baltimore, Md., Mar. 27-29.

APRIL

SAE Aeronautic Meeting and Production Forum, New York City, Apr. 2-5.

Spring meeting, American Rocket Society, Sheraton-Park Hotel, Wash., D. C., Apr. 3-6.

British Radio and Electronic Component Show, Grosvenor House and Park Lane House, London, England, Apr. 8-11.

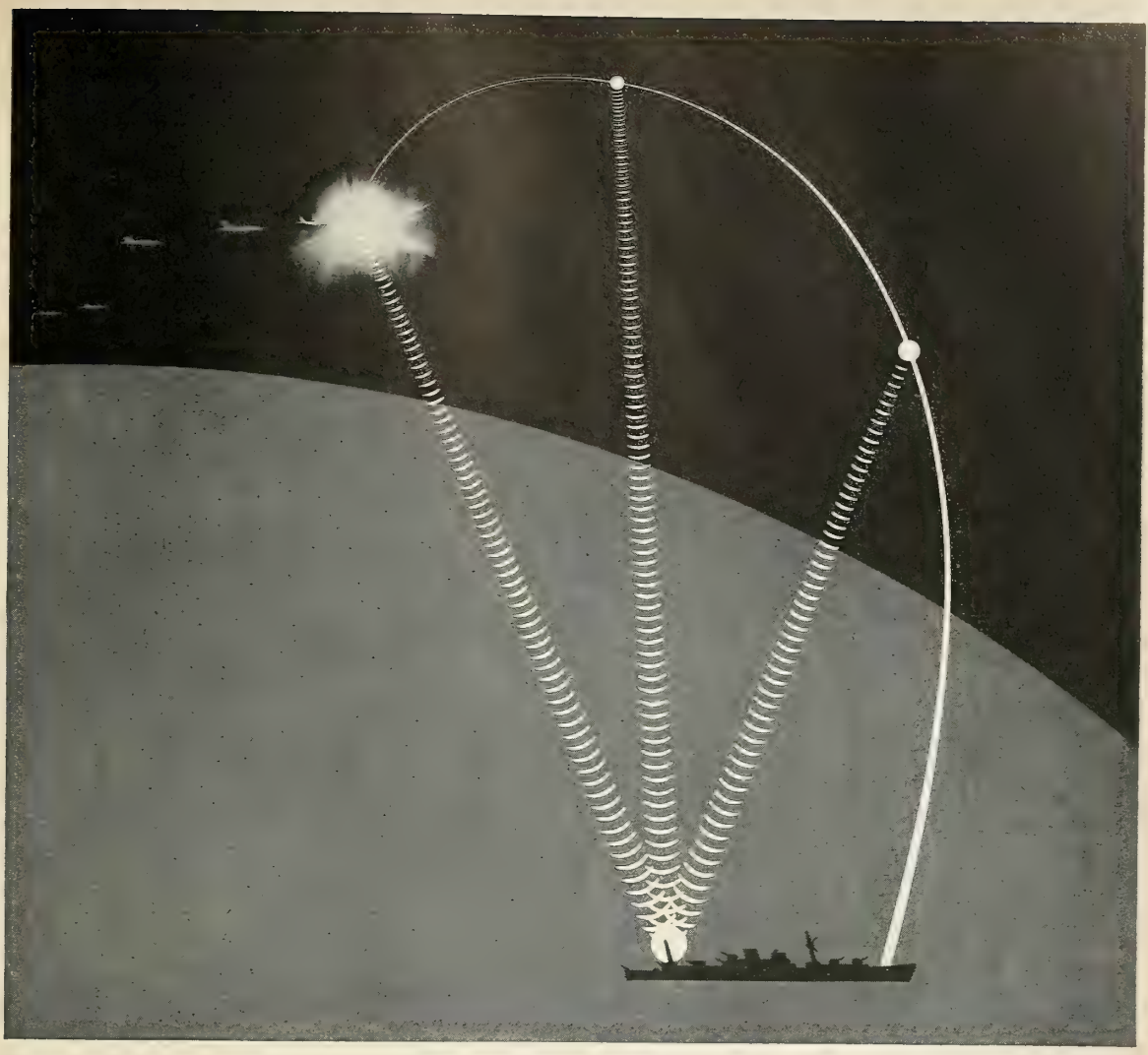
Annual Industrial Electronics Educational Conference, sponsored by IRE, Armour Research Foundation, Ill. Institute of Technology, Chicago, Ill., Apr. 9-10.

Southwestern IRE Conference and Electronics Show & National Simulation Conference, sponsored by IRE, Shamrock-Hilton Hotel, Houston, Texas, Apr. 11-13.

IRE PGTRC National Symposium on Telemetering, Phila., Pa., Apr. 14-16.

IRE Professional Group on Telemetry and Remote Control, national symposium, Phila., Pa., Apr. 15-17.

Symposium on Nondestructive Tests in the Field of Nuclear Energy, Morrison Hotel, Chicago, Ill., Apr. 16-18.



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Manned Rocket Bombers Underway

Soviet and U. S. Enter Race For Space Craft Of 10,000 Mile Range

By Erik. Bergaust

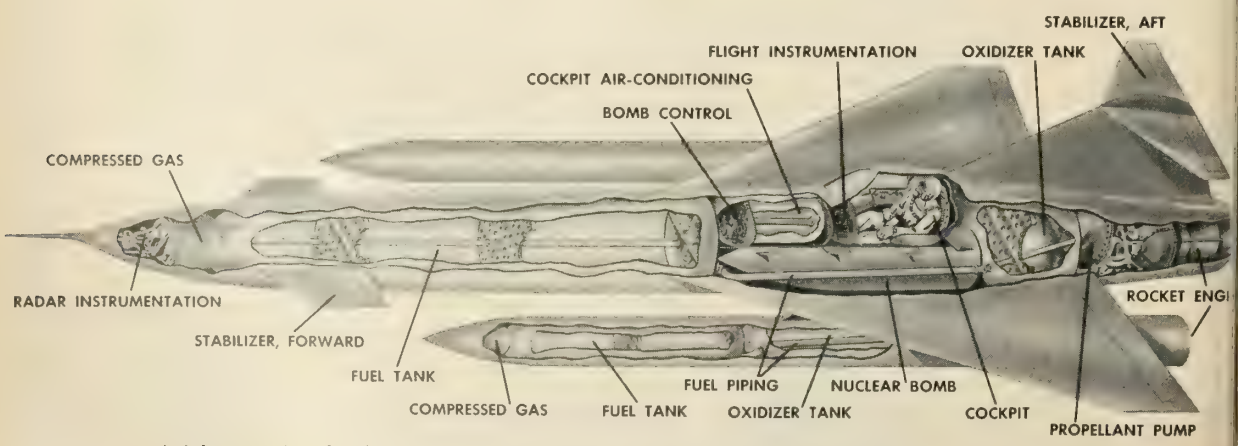
The Soviet and US now are believed to be entering a red-hot race for the next step in ultra-modern warfare. What comes after the ICBM? The answer, according to several experts, is the manned space-rocket bomber, an entirely different concept in weaponry and the greatest technological challenge yet. This supercraft supposedly is a missile with a man it, designed to cover distances up to 10,000 miles. Several US companies have expressed interest in the project, and it is safe to assume that study contracts have been awarded. Among the companies mentioned in this connection are Convair and Bell.

The Soviets have shown great interest in manned space bombers ever since the end of World War II. In fact, the reds tried to pursuade Dr. Eugen Sanger, designer of the antipodal bomber, or skip bomber, to go to work for them. Dr. Sanger, turned down the offer, whereupon the Soviets tried to kidnap him. However, Dr. Sanger is safe in Stuttgart, where he heads up a jet propulsion institute and is working on such advanced projects as ion rockets.

The antipodal bomber concept was conceived by Dr. Sanger during the last war as a possible solution to direct bombardment of targets on the United States mainland from launching sites in Europe. The manned missile would be launched into areopause altitude, approximately 120 miles up, and then behave like a ballistic missile, i.e. it would decend back toward earth in a ballistic path. However, hitting the denser layers of the atmosphere the missile's wings would provide "lift" and bounce the vehicle up into thinner atmosphere layers again, aided by bursts from the rocket engine. It has been calculated that only three of these bounces would be necessary for the bomber to cover the distance from Europe to the United States.

When Dr. Sanger's glide-and-rocket bomber was revealed after the war, many experts could not help being skeptical about the concept. But these same experts seem to think differently today. Although the forthcoming space bombers may or may not be skip-or antipodal vehicles, the feasibility of sending a manned space rocket craft over a distance of 10,000 miles is obvious. It seems, however, that it will take at least two or three years to develop a rocket bomber prototype, if work on it got underway today. And, in all probability, both the Air Force and Navy would want to gather some experience with the high-altitude research aircraft now being built before attempting to design the bomber.

Reports gathered for this issue of m/r indicate the Russians have been working on an advanced version of the Sanger craft, and that its designation is T-4A. A manned as well as an unmanned version are believed to have been attempted. Some of the reports



Artist's conception of Red rocket bomber that would climb to 120 miles and cover a distance of 10,000 miles.

indicate the manned version will be track-launched and that it could cover the distance between Leningrad and New York in 89 minutes.

We are rather skeptical about any statement to the effect that the Russians have advanced to the hardware stage in manned rocket bomber development, but, as has often been proven, it is quite probable that they are on a par with us in this field as well.

Adding up the information we have obtained on the Red rocket bomber, it appears their super craft would be between 60 and 70 feet long. It would be fitted with three liquid rocket engines, all burning kerosene and liquid oxygen. The two smaller, wing-mounted engines and their tanks and turbine gear will be jettisoned after burnout during the initial climb to 120 miles. The vehicle also will employ a large-size booster for the run along the rails or tracks that supposedly will be used for takeoff.

The ship have a delta-wing and T-tail stabilizer. Fuel tank is located in the main fuselage section forward of the cockpit, oxidizer tank is directly behind pilot. Bomb compartment is directly underneath the cockpit.

US Air Force planners—naturally—have no comments to offer on our own efforts in the field of manned space-rocket bombers, but many industry officials believe the Air Force is about to undertake "something big" and "real sophisticated" in this field. Funds for whatever work is being done now probably come from R&D grants.



According to the Italian aviation publication "Alata" this is the way the Russians contemplate to launch their rocket bomber. Bomb is to be dropped on New York. Pilot will be picked up by sub in the Pacific.

IRBM, ICBM Get Super-Priority

HUNTSVILLE, Ala.—Officials of the Army Ballistic Missile Agency and Redstone Arsenal have received notification that the U.S. Department of Commerce has assigned top priority to the IRBM and ICBM research and development programs. The order will specifically affect work on the *Jupiter*, the Army's intermediate range ballistic missile. Supposedly, the *Jupiter* prototype is being readied at Patrick AFB for firing. The order also applies to USAF and Navy programs in the same fields.

The top priority will be helpful to contractors in the procurement and purchase of scarce materials and components. It applies to them and to all others engaged in research, development and production of the weapons.

This is the first time that the super-priority has been applied to programs of the IRBM and ICBM scope.

Russians Hold IRBM Lead?

Moscow now seeks to confirm what some American scientists have been saying privately for some time—that Russia is leading the United States in some significant categories of guided missile development.

Pravda, the official Communist party newspaper, had this to say the other day:

"It is common knowledge that the United States is far from being a monopolist e i t h e r in the sphere of nuclear weapons or, even less so, in the sphere of long-range missiles.

"Here it would be more appropriate to talk of America's lag."

The jibe at American missile technology was contained in a lengthy Soviet warning to o t h e r countries against p e r m i t t i n g establishment of U.S. atomic military contingents on their territory.

The warning included the threat of nuclear retaliation by the Soviet Union, possibly by missile delivery, in the event of war.

Pravda said that the U.S. Defense Department "intends to station atomic groups armed with the latest types of guided missiles in troubled areas."

And it quoted from President Eisenhower's budget message references to increasing the number and variety of nuclear weapons and a 35 per cent increase in guided missile expenditures.

"How can these aggressive plans be reconciled with the dulcet speeches of (Henry Cabot Lodge) U.S. representative to the United Nations, who urged the world the other day to abandon the tendency of stockpiling atomic weapons, to reduce the atomic threat in the future, to bring about a situation where scientific research in the sphere of jet-propelled missiles would be devoted to peaceful scientific purposes," *Pravda* asked.

State Department officials refused to take too seriously the Soviet threats against our allies.

But they, together with Pentagon planners, wondered precisely what the Reds have under development to back up the boast that the U.S. is lagging in long-range missile development.



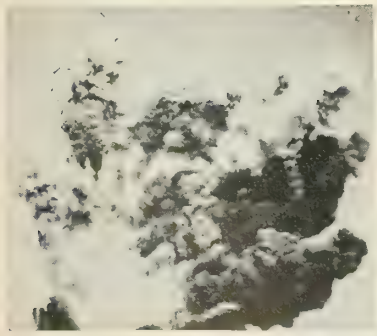
While the Russians claim they have plenty IRBMs and while reports say they are equally advanced in the field of ICBM development, the United States is in position to show off an actual piece of ICM hardware—and a production model at that: Northrops SNARK.

$533 Million More for Guided Missiles

Six Billions to be Spent in Next Two Years . . . Research and Development Grants Cut







Army has released photographs of its field weapon Lacrosse. Development of this weapon has highlighted accuracy and mobility, according to the Army. These pictures also indicate striking power. "The Lacrosse is a deadly accurate guided missile for close tactical support of ground troops in the field," Redstone spokesmen said. It is mounted on a mobile launcher. First pictures show several of the missiles mounted on the launchers which was taken to indicate that Lacrosse is in at least small quantity production and that field units are being trained in its use.

The Defense Department will spend more money for guided missiles in the 12 months beginning July 1 than ever before in history. New orders for missiles will be second only to the current fiscal year.

According to Wilfred J. McNeil, Assistant Defense Secretary (Comptroller), the Army, Navy and Air Force will spend $2,039,000,000 for missiles of all categories during fiscal 1958 and will have an additional $2,563,000,000 available for missile procurement during the same period.

President Eisenhower's budget for 1958, which calls for $38 billion in new money and $38.5 billion in expenditures for the Defense Department, indicates that "expenditures for guided missiles will be up 35 per cent" during the coming year while procurement of manned aircraft will remain at about the same level and ship construction will be up 12 per cent over fiscal 1957.

The Pentagon comptroller provided the following comparisons of missile expenditures and money available for missile obligations over an eight-year period. The figures include all of the military services.

Defense Department Guided Missiles

	Expenditures	Available for Obligation
Fiscal 1951	$21,000,000	$424,000,000
Fiscal 1952	169,000,000	468,000,000
Fiscal 1953	295,000,000	896,000,000
Fiscal 1954	504,000,000	748,000,000
Fiscal 1955	718,000,000	345,000,000
Fiscal 1956	1,168,000,000	938,000,000
Fiscal 1957 (est.)..	1,506,000,000	2,300,000,000
Fiscal 1958 (est.)..	2,039,000,000	2,563,000,000

McNeil indicated the new money being requested would enable the Air Force to finance either the Chrysler *Jupiter* or the Douglas *Thor* 1500-mile-range ballistic missiles but not both. The same, he added, is true of the Army, which will have to decide between the Douglas-Western Electric *Nike Hercules* and the Bendix *Talos* surface-to-air weapons to replace *Nike Ajax*.

The Defense Department's budgetary expert gave the following indications of missile expenditures and available money for each of the services during the 1951-58 period.

Army Guided Missiles

	Expenditures	Available for Obligation
Fiscal 1951	.....	$173,000,000
Fiscal 1952	$46,000,000	253,000,000
Fiscal 1953	119,000,000	301,000,000
Fiscal 1954	187,000,000	225,000,000
Fiscal 1955	238,000,000	.....
Fiscal 1956	333,000,000	.....
Fiscal 1957 (est.)..	425,000,000	.....
Fiscal 1958 (est.)..	562,000,000	425,000,000

Navy Guided Missiles

	Expenditures	Available for Obligation
Fiscal 1951	$5,000,000	$130,000,000
Fiscal 1952	56,000,000	119,000,000
Fiscal 1953	95,000,000	181,000,000
Fiscal 1954	141,000,000	159,000,000
Fiscal 1955	176,000,000	126,000,000
Fiscal 1956	195,000,000	238,000,000
Fiscal 1957 (est.)..	221,000,000	352,000,000
Fiscal 1958 (est.)..	264,000,000	428,000,000

Air Force Guided Missiles

	Expenditures	Available for Obligation
Fiscal 1951	$16,000,000	$121,000,000
Fiscal 1952	66,000,000	95,000,000
Fiscal 1953	81,000,000	414,000,000
Fiscal 1954	176,000,000	364,000,000
Fiscal 1955	305,000,000	219,000,000
Fiscal 1956	641,000,000	700,000,000
Fiscal 1957 (est.)..	860,000,000	1,948,000,000
Fiscal 1958 (est.)..	1,213,000,000	1,710,000,000

President Eisenhower's budget message shows that the total new money request for missiles in fiscal 1958 is $2,646,000,000. This sum includes $425 million for the Army, $428 million for the Navy and $1,793,000,000 for the USAF.

McNeil reports that if this new obligational authority is voted by Congress, the sum will be coupled with carryover and other funds and will result in new direct obligations during fiscal 1958 of $2,828,000,000 for missiles. The $2,828,000,000 will include direct orders by the Army for $673 million, by the Navy for $465 million and by the Air Force for $1,690,000,000.

Direct obligations figure, compares this way for the 1956-1958 period.

Direct Obligations for Missiles

	FY 1958	FY 1957	FY 1956
*DD	$2,828,000,000	$3,071,000,000	$1,630,000,000
*A ..	673,000,000	743,000,000	439,000,000
*N ..	465,000,000	440,000,000	222,000,000
*AF	1,690,000,000	1,888,000,000	969,000,000

*DD—Defense Dept.
*A—Army
*N—Navy
*AF—US Air Force

McNeil declares that there will actually be an increase in obligations for missiles between fiscal 1957 and 1958, if the ballistic program is discounted. Across the board, he says, more missiles are to be ordered in the coming year. The more than $3 billion scheduled to be obligated during the current fiscal year includes much of the initial groundwork for the IRBM (*Jupiter* and *Thor*) and the ICBM (Convair *Atlas* and Martin *Titan*) program, and will inevitably drop off in 1958, McNeil states.

On the research and development side, the Presidential budget message indicates a total of $331,800,000 is to be obligated in fiscal 1958 by the three services for "guided missile and related equipment" R&D. The respective figures for 1957 and 1956 are $346,500,000 and $280,400,000.

Isolation of the R&D activities in the guided missile field by the Army, Navy and Air Force shows the following comparison:

Research and Development (Guided Missiles and Related Equipment) Program and Financing

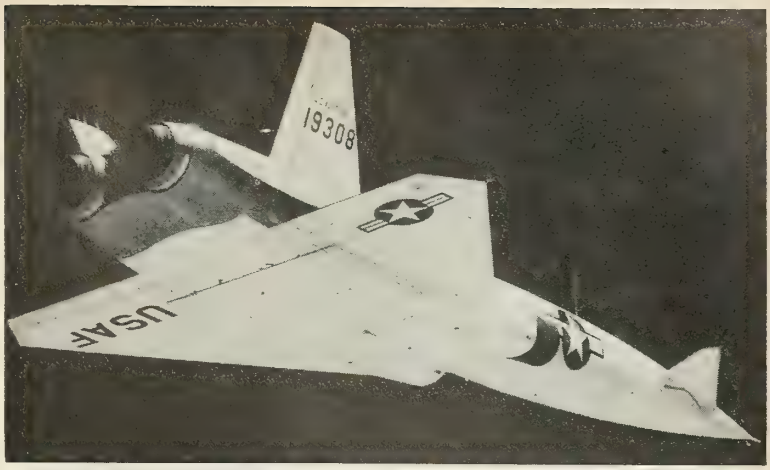
	Army	Navy	USAF
Fiscal 1956	$111,953,992	$95,226,874	$73,279,983
Fiscal 1957 (est.)..	108,985,000	146,219,035	91,327,081
Fiscal 1958 (est.)..	87,380,000	167,963,000	76,412,000

It becomes readily apparent that some guided missiles in the research and development stage in 1956 and 1957 are to be funded out of procurement money for 1958.

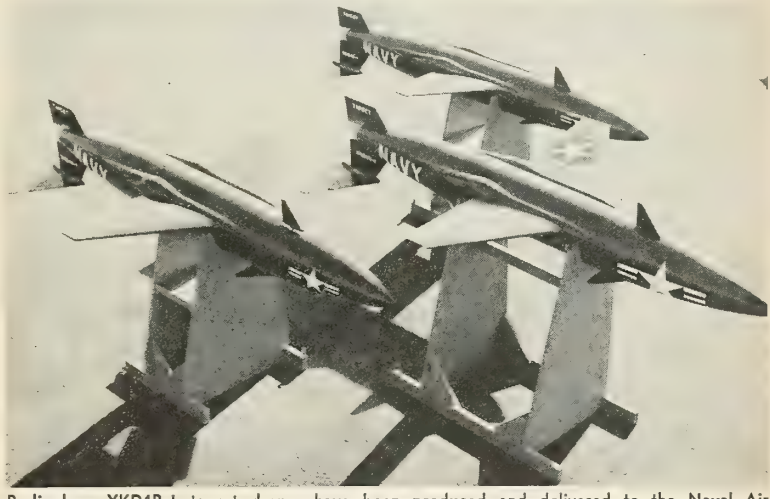
- The Army's missile R&D money shows a $21.6 million drop between 1957 and 1958. Its direct obligations for missiles also will decrease $70 million during the period. Spending will climb by $137 million.
- Navy R&D activities in the missile field rise by $21.7 million (presumably to cover the ship-based *Jupiter* IRBM and the sub-based *Polaris*, among others) and its direct obligations will climb by $25 million between 1957 and 1958. Spending will rise by $43 million.
- USAF missile research will fall off by $14.9 million and its direct obligations also will be down by $198 million. Spending will be up by $353 million.

Summarizing the 1958 Defense Department figures as a whole:

- Missile R&D will be down $24.8 million from 1957.
- Direct obligations for missiles will decrease by $243 million.
- Spending for missiles will rise by $533 million.



Sleek X-10 NAVAHO test missile built by North American. This is our second intercontinental missile, Northrop's SNARK being the first one—and closer to production.



Radioplane XKD4R-1 target drones have been produced and delivered to the Naval Air Missile Test Center at Point Mugu, California. The missiles are built under a Navy contract.

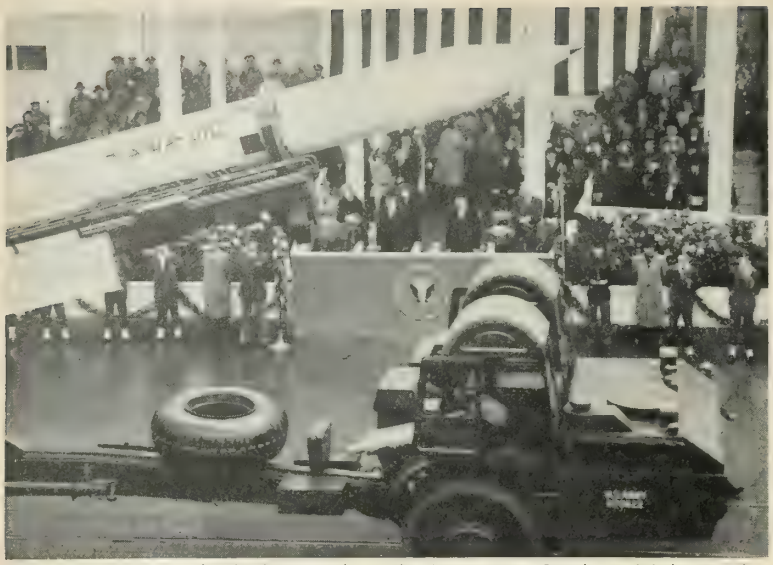
Biological Research In Satellites?

A committee of the Space Medicine Association has been formed to plan for biological and medical experiments in the U.S. earth satellite program. The committee, chaired by the Association's President, Dr. Fred A. Hitchcock of Ohio State University, has as members, four leading space medical investigators: Dr. Hubertus Strughold (USAF Department of Space Medicine, Randolph Field), Dr. Heinz Haber (University of California), Dr. (Major, USAF) David G. Simons (Holloman AFB), and Dr. Hermann Schaefer (NAS, Pensacola).

None of the physical experiments contemplated for the U.S.-IGY satellite program are in the fields of biology or medicine. The function of the Association's committee will be to plan a "definite and worthwhile" research program so that space medical researchers will be ready when space and weight are allotted for such experimentation aboard future satellites.

Queried as to Russian interest in such matters, one member of the Association commented that he "wouldn't be surprised" to see such experimentation "early" in the Russian satellite program. "We all know we'll be experimenting in that medium eventually, and I think the Russians would like to be first," he stated.

The Space Medicine Association is a subsidiary organization of the Aero Medical Association, the professional society of aviation physicians and flight surgeons.



Guided missiles gave the finishing touch to the Inauguration Parade in Washington last month. The Army managed to raise the Corporal—in salute—as the launching van passed the presidential stand.



Lockheed proudly displays its X-17 re-entry test missile. Vehicle is said to have made numerous successful flights. Note bulky spin stabilizer rockets mounted on first stage.

Big ARS Meeting In Washington This Spring

The Nation's capital will be the scene of the National Annual Spring Meeting of the American Rocket Society. Illustrated lectures on space flight, earth circling objects, and rocket vehicles will be presented.

The national meeting will be held at the Sheraton Park Hotel, Washington, D. C. April 3 to 6, 1957. More than a thousand experts are expected to be on hand.

One of the principal features of the Spring Meeting will be the exhibition of physical objects and displays staged by the American Rocket Society on rockets, guided missiles, satellites and concepts of space ships—including their components, materials and accessories.

Expected to be included in the exhibit are actual guided missiles, full scale rocket and ramjet engines, a prototype of the *Vanguard* satellite, instrumentation and guidance equipment for missiles, telemetering apparatus, tracking systems, data reduction equipment, and many accessory and component items. Companies interested in booth space should contact ARS in N.Y.

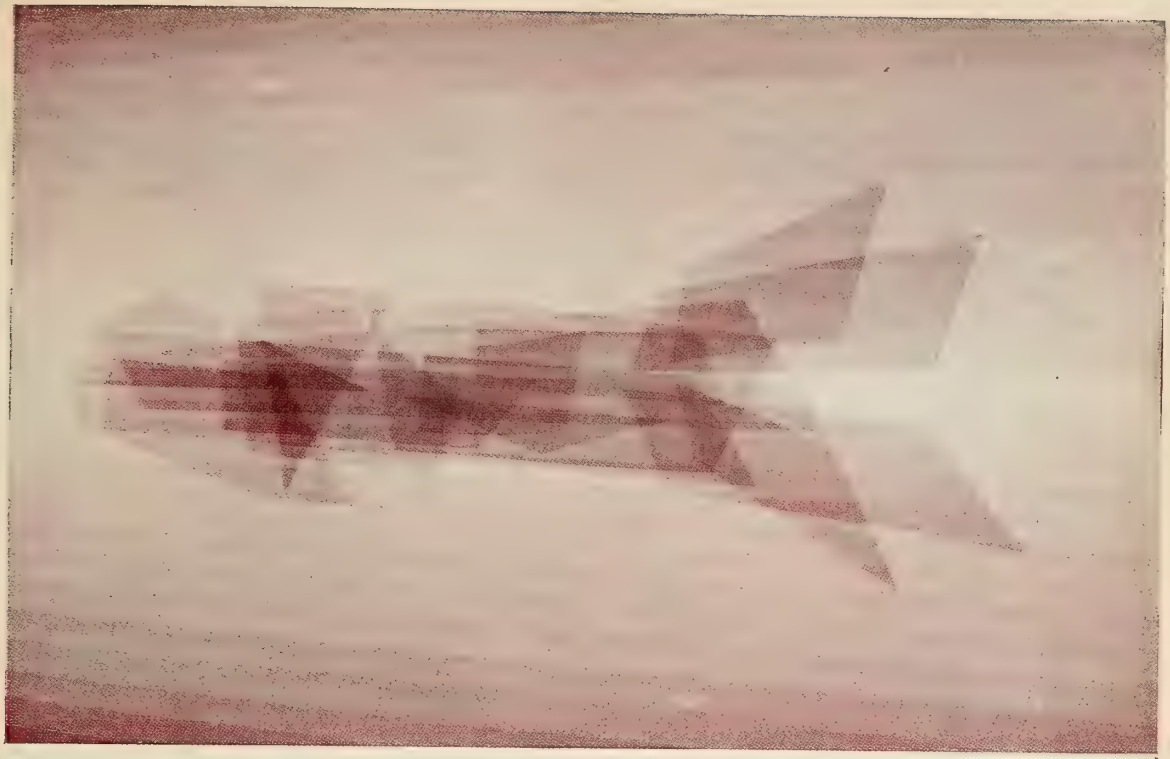
The Spring Meeting was originated by Erik Bergaust, President of the National Capital section of the American Rocket Society and Managing Editor of MISSILES & ROCKETS. Meeting Chairman is Andrew G. Haley, formerly National President of the American Rocket Society and for several years Vice-President of the international Astronautical Federation. Chairman of the National Program Committee is Kurt R. Stehling.

Luncheon speaker and the chairman of the April 4 afternoon session is Doctor Theodore von Karman.

Throughout the sessions, similar renowned experts will give papers, conduct illustrated lectures, and present breakfast and luncheon talks. Extensive program for ARS members' wives is planned.

The meeting will center around four principal themes, namely, Space Sociology, including Medicine, Law, Education and Economics; High Speed Rocket Test Tracks; Propulsive Systems; and the *Vanguard* project, including discussion of the progress of the International Geophysical Year.

More than 300 members of the International Society of Aviation Writers will meet in Washington at the same time. The writers will be invited to attend the ARS sessions. (See "People" page 118).



"ROCKETS", one of a series of paintings by Simpson-Middleman, a team of artists with the rare ability to translate scientific fact into creative imagery. Here, the rocket's blast and its guiding beam are thought of as a single stream of light through the center. Darks and lights of definite shape in a weak visual vector field are relied on to suggest the "wobble" caused by the acts of the servo-mechanisms in making their adjustments. Painting courtesy John Heller Gallery, Inc.

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Huntsville Braces for ABMA Expansion Program

HUNTSVILLE, ALA.—The reported misfiring of the USAF *Thor* ballistic missile in its first tests at Patrick Air Force Base, Fla., had immediate repercussions in this city, home of Redstone Arsenal and the Army Ballistic Missile Agency where the *Jupiter* IRBM was developed.

Only a few hours before the report of the *Thor* fizzle was published, Maj. Gen. John B. Medaris, ABMA commander, made a strongly worded appeal to the annual dinner of the Chamber of Commerce for a broad program of civic expansion. His words acquired special significance in the light of the next day's announcement.

"There is more work to be accomplished in the missile field than there are people to handle it. Consequently, I see nothing but increased activity here for some time to come. We will have even greater responsibilities than ever before," he declared.

The Medaris speech came as a bracing tonic to the city which, under the impetus of Redstone and ABMA, has expanded from 16,000 people in 1950 to almost 60,000 today. The area had been fearful of cutbacks and wholesale transfers of missile and rocket personnel and equipment since Secretary of Defense Wilson issued his memorandum late in November giving the Air Force jurisdiction over all missiles with a range of more than 200 miles. Even the m/r story of November, giving first details of the highly successful first flight of the *Jupiter* and pointing out that full development of *Thor* would require another two years of intensive work did little to lift the gloom that had settled over the area.

Planning for expansion of the city's school, water, sewage and gas systems, which had been delayed when the Wilson memorandum was made public, has now been resumed. A program for some 750 new low-cost houses which also had slowed was stepped up. New tax rates are going into effect in both city and county to finance the expansion of services.

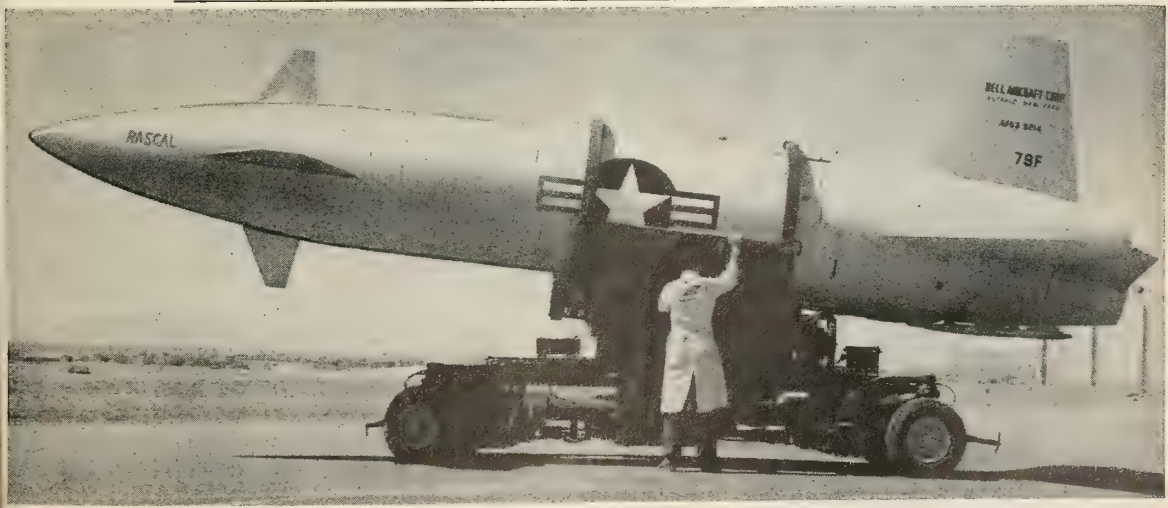
Medaris is repeating his prediction of a year ago that Huntsville will be a city of 100,000 persons by 1960, and the city believes this can only mean that there will be a huge expansion of work at the Arsenal and ABMA, with the Air Force coming in, even reluctantly, to benefit from the work of the famous von Braun group.

The impact of Arsenal and ABMA personnel upon the city was aptly illustrated recently when Hannes Luehrsen, a member of the group, proposed an ambitious plan for remodeling of the city's 150-year-old court house square to provide a magnificent two-mile mall and civic center through the very heart of the city, with parks and lagoons. Luehrsen once prepared similar plans for the city of Berlin. He was also a prime mover in planning of the new four-lane Memorial Parkway which now traverses the city and has sparked a new wave of commercial construction that is actually shifting the business center of the city to the super-highway. The new proposal was made public on one-half of the front page of the local daily.

Underlining the Medaris plea for adequate civic facilities is the fact that the Army since the Wilson memorandum has quietly been transferring large numbers of skilled personnel from other arsenals across the country to Huntsville. A group of 75 new people came in during one week in January from an Eastern arsenal, and applications for employment at the Arsenal have risen from the normal average of 1,250 per month to 2,000. Personnel directors say they expect no slackening of this tempo during 1957.

Indicative of the community's optimism is its reaction to the closing of one of its largest industries, a cotton mill that had functioned here for more than half a century. Only five years ago such a closing would have been a calamity. Now, however, the Huntsville Industrial Expansion Committee regards it as an opportunity for further growth. A group of local leaders now plans to purchase the mill and make its five buildings and 800,000 square feet available to new industries, with heavy emphasis upon those participating in the ballistic missile program. Most of the 700 textile workers made idle are being rapidly absorbed into other jobs.

Informed opinion seems to be that the Army, within the scope of the Wilson memorandum, is now concentrating more of its effort at Redstone and ABMA and will continue to do so; that there is now the chance that the Air Force will not be so reluctant to begin financing ABMA when the new fiscal year begins on July 1st; and that these developments foreshadow the buildup of a real missile and rocket production industrial complex that may make this one-time sleepy little Southern town truly "Rocket City, U.S.A."



Air Force has permitted Bell to release picture of the Rascal—after skilled artist eliminated sonar-type radome and reshaped the nose.

Sharp Criticism by Symington on U.S. Missiles

After a million words of testimony, Senator Stuart Symington's Air Force Subcommittee last month issued its report. Here follow excerpts from the conclusions of that report having to do with missiles and the Soviet threat.

"The vulnerability of the United States to sudden attack has increased greatly during the past decade and this vulnerability will continue to increase in the foreseeable future.

"The Department of Defense has failed to develop an adequate defense warning system.

"The direction and planning of naval strength again leaves the United States vulnerable to submarine attack against our shipping, and particularly vulnerable to submarine missile attack on military and civilian targets within our heartland.

"The Soviets are rapidly closing the qualitative gap. Yet, our qualitative lead is now being given as justification for our having passed over to the Soviets quantitative superiority in military airpower.

"The duplicating approach characteristic of many research and development programs in the Department of Defense, along with the dollar limitations established for such programs, has retarded needed modernization of weapons systems.

"These policies have retarded important scientific breakthroughs. They contrast with Soviet policies which have produced extraordinary Soviet progress in the research and development field.

"The Soviets exceed the United States in rate of technological development, in training facilities, in speed and quantity of prototype development, in the training of scientists and engineers, and in many other phases of airpower development.

"The Department of Defense has permitted duplication, even triplication, among the three services in the development and production of missiles; and has permitted comparable waste in the allocation to the three services of responsibility in the missile field.

"The Department of Defense also delayed in giving overriding priority to the ballistic-missile program. As a result, there has been a serious loss of time as compared with the rapid progress of the Soviets in this field.

"Financial considerations have often been placed ahead of defense requirements, to the serious damage of our airpower strength relative to that of Russia; and hence to our national security.

"The United States has the capacity to produce and maintain airpower which is relatively stronger than that of the Soviets; but the Department of Defense has not utilized this capacity.

"With proper programing and administration in the Department of Defense, it would be possible to maintain air supremacy over the Soviets without jeopardizing a sound economy and without imposing additional tax burdens upon the people.

"Under our form of government, the American people have not only the right, but also the need, to receive all information about our national defense which would not help a possible enemy. Nevertheless the public is neither adequately nor accurately informed about our military strength as against the great and growing military strength of the Communists.

"The public has failed to receive from official sources complete, accurate and timely information which it has the right to know.

"The subcommittee recommends that the deficiencies in military strength, as pointed out . . . be corrected as promptly as possible.

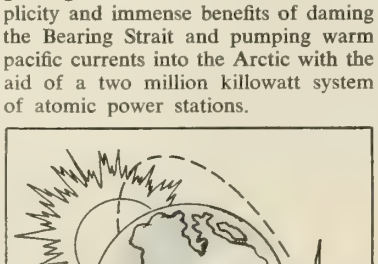
Russian Space Satellite Propaganda

The January issue of USSR, the Soviet propaganda magazine published in the U. S., skips lightly over such warmongering projects as ICBM and IRBM and paints a rosey picture of tomorrow—a day that, "relatively speaking is around the corner," USSR says, when man will send fission-powered suns into space to light and warm the Arctic icelands into verdent lands of Eden.

Also, as you read this issue of USSR, you're told of intercontinental ballistics passenger liners serving contented passengers vodka and sturgeon roe, while the hot little hazard to space navigation mentioned above speeds brightly across the rocket's bow.

In one article entitled "Excursion Into the Future", Soviet writer Vasili Zakharchenko suggests an artificial satellite "shot up into cosmic space" that will orbit the earth at an altitude of hundreds of thousands of miles. This "helio-satellite" would be powered by controlled fusion and would glow brightly over the cold polar regions. But by preset controls—in the middle of this 100,000,000° hot spot presumably—it would switch to low power and glimmer only dimly, conserving its fissile fuel, when passing over the earth's more temporate zones.

Writer Zakharchenko, doubtlessly only because he didn't wish to bore his non-technical readers, decided not to even suggest how all this might be done. In the same article, there's a glowing account of the relative simplicity and immense benefits of daming the Bearing Strait and pumping warm pacific currents into the Arctic with the aid of a two million killowatt system of atomic power stations.

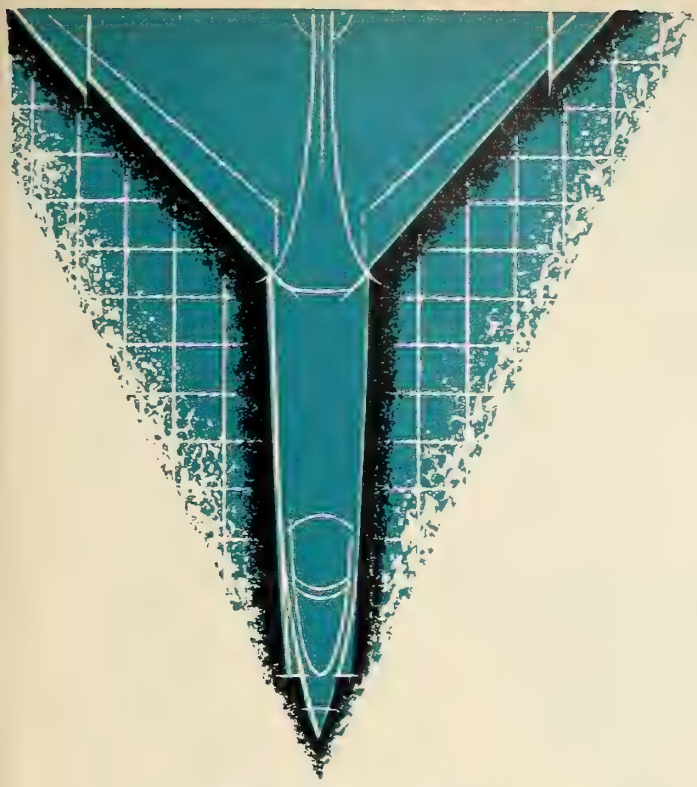


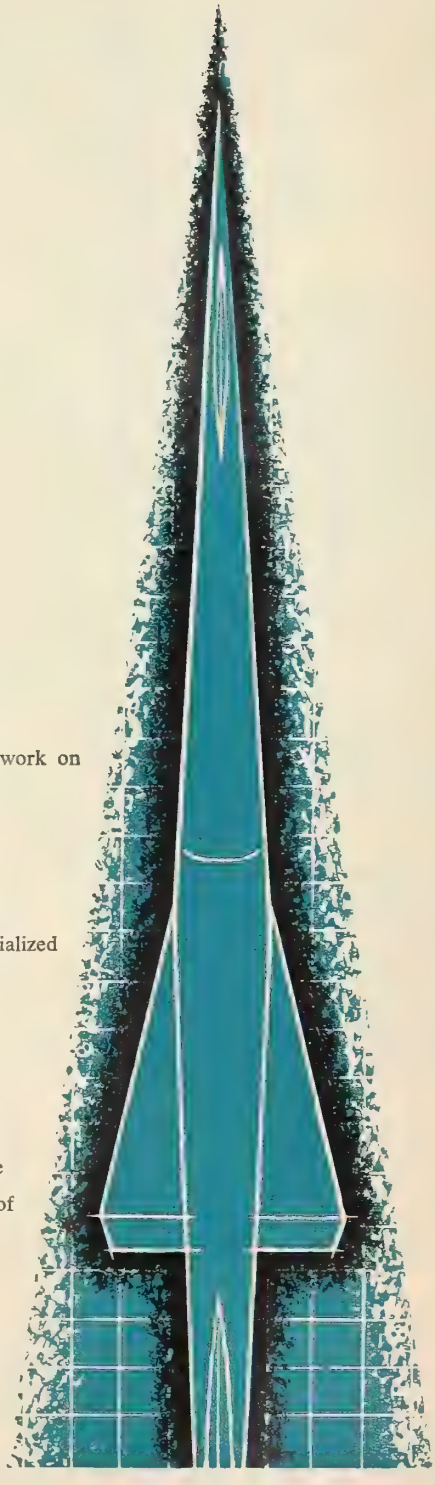
Soviet Rocket Launcher Revealed

When the British entered Port Said in Egypt, they found a large cache of Soviet arms. Among the captured items was a Russian rocket launcher. The anti-tank weapon is surprisingly similar to our old 2.36-inch rocket launcher, the "Bazooka." Indeed, dimensions appear to be highly copied. However, there are some differences, since the Russians have had over ten years to make changes. These modifications are:

1). New fuze.
2). Driving bands on the rocket body (the rocket may be spin stabilized).
3). Blast holes visible on the rocket tube motor (prehaps to vent combustion gases forward to increase muzzle velocity and/or to imprint spin).
4). Large rear cannister (for use either as a barrel wing or for loading into launcher tube only).
5). Shorter launching tube (by about ½-ft) than our old "Bazooka."

Each round is about 17-18 inches long and has a diameter of 60-70 mm. Weight is 3-4 lb. The launcher is about 4 feet long. Construction is extremely rugged and of good quality. Performance characteristics are unknown.





DESIGN ENGINEERS

Perhaps you are wondering which way to turn for real pioneering work on a complete aerial weapon. The missile field offers you a role in advancing our newest family of weapons. Fighter aircraft offer an increasing challenge in human engineering as we equip pilots for new speed and space conquests. In both fields, unique attractions for imaginative designers abound. Yet seldom in today's ultraspecialized organizations is the designer privileged to contribute to *both* fighter and missile development. An exception is Chance Vought's integrated missile and fighter design organization. Here's a rare opportunity to experience the varied career advantages of piloted and pilotless weapons, and to apply applicable design lessons of one field to the other. There may be a place for you with the developers of the Regulus missile and Crusader fighter. Send a resume of your background to:

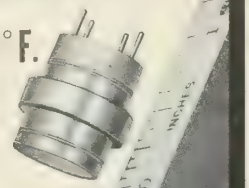
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Rocket Trends

By Erik Bergaust

Russia's missile arsenal is vast. In fact, as our editors put together the bits and pieces of information for this issue, and as we finally arrived at some kind of analysis, we had before us a pretty complete picture of a nation that truly has become a mass producer of rockets. We learned that Red missilry and rocketry for the first five post-war years were based solely on German hardware and know-how. But since 1950 the Russian military machine has produced weapons of communist designs. We also learned that the Soviets do not tend to build up complex arsenals consisting of a variety of missiles, rather they concentrate on a few standard weapons—probably because they can achieve weapon system reliability and simplicity in this manner.

Furthermore, we have learned that two of the Soviet's operational missiles—counterparts to our *Honest John* and *Redstone*—namely the T-7A and the *Comet* are being produced by the thousands. As a matter of fact, the Russians gladly donated a T-7A to the Polish astronautical exhibition that is currently touring satellite countries *(see page 74)*. The *Comet*—which intrigues us immensely—is Russia's 650-mile rocket (thus it exceeds the *Redstone* in range); this is the Korolov rocket, or M-102, which has been confirmed to us by several reliable sources. These sources also say the Russians have produced at least 20,000 of the M-103, an IRBM-type vehicle which is said to have a range of 1,800 miles. Now, a stockpile of 20,000 IRBMs is indeed frightening—when you know that we haven't yet started production on the *Thor* or the *Jupiter*.

Speaking of our own IRBMs, it is interesting to note that while the powerplant for the *Jupiter* has been referred to as a 150,000 pound thrust engine, the Russian IRBM, in spite of the fact that its range is said to be 1,800 miles, uses a 250,000 pound first-stage rocket and a 77,000 pound second-stage unit. This leads us to believe Russian hardware is bulkier and heavier with more dead-weight, and, designwise, we therefore are ahead of them. Our missiles might be more compact, and if you will, more "streamlined"—nevertheless, such comparisons do not serve much purpose. What counts is the fact the Russians are on a par with us, and capable of employing long-range missiles today.

We often ask oursleves how the Russians possibly could have obtained the know-how and skills that are required to build up the missile and rocket potency which they now possess. Certainly, these results do not stem from German or other foreign aid, although such assistance might have been helpful in the early years. It seems, however, that Senator Symington has a good point when he stresses that the Reds are capable of gaining rapidly in the technological race between our two countries, because their war industry doesn't suffer from the bureaucracies that are so unavoidable in a democracy. Another point: the communists know only too well how dangerously they are surrounded by our "threatening, imperialist" bases, and the answer—in the communist mind—might be a great amount of launching sites and an equally vast amount of missiles.

Finally, let us mention that it took quite a bit of doing to get this issue out. And we are grateful to all our editors, correspondents and contributors and to our special sources overseas. This issue, with some 40 pages of editorial material on Russian missiles, rockets and astronautics, is the result of compiling and sorting and checking hundreds of reports, articles and books. Particularly, we wish to emphasize the tables on Russian missiles on pages 36 and 37—to the best of our knowledge, this tabulated presentation is the first ever attempted in this country. These tables, mapping the Red missile arsenal, give a good picture of the trends behind the Soviet's missile goal. Indeed, we hope we shall never experience the activation of this arsenal.

ABMA Has First Birthday Party

Huntsville, Ala.—The Army Ballistic Missile Agency observed its first anniversary on Feb. 1st with a celebration as close to an "open house" as that closed post will permit.

Several hundred civic leaders of Huntsville and the surrounding areas were special guests and were escorted on a limited tour of the facility, shown recently completed movies that are being used for recruiting purposes and were treated to a brief demonstration of a missile being fired from a test stand.

In its first year, the ABMA has expanded from a handful of military and civilian employes to an organization of some 4,300 persons and, judging from stepped-up employment in recent weeks, may well double its personnel during the coming year.

The dollar value of the physical facilities has jumped by some $10 million from $46 million a year ago.

Nearly $26 million in construction is under way at present, and an additional $20 million is being planned.

The Army's first *Redstone* missile battalion, the 217th Field Artillery, has been formed and is now being trained at ABMA.

NATO Delegations Visit at Redstone

Huntsville, Ala.—Six officials representing the Federal Republic of Germany (West Germany) received an orientation course in missile and rocket development and use at Redstone Arsenal and Army Ballistic Missile Agency recently.

The German delegation included four retired military officers: Lieut. Gen. Wolfgang Vorwald and Cols. Joachim Luetzow, Maximilian Bohland and Kurt Braennig; and Dr. Walter Hofmeir and Mr. Otto Baier. Their visit was under auspices of the U.S. Departments of State and Defense.

The concern of the NATO defense forces with missiles and rockets has been mounting steadily, observers note, since the announcement in 1954 that the jet fighter-bombers supplied to them under the Mutual Defense Assistance Program were capable of using missiles and rockets with nuclear warheads, and the subsequent stationing abroad of U.S. Army and Air Force units equipped to fire such weapons. The first school for NATO forces dealing in atomic weapons is said to have been held at Oberammergau in the Bavarian Alps some time ago.



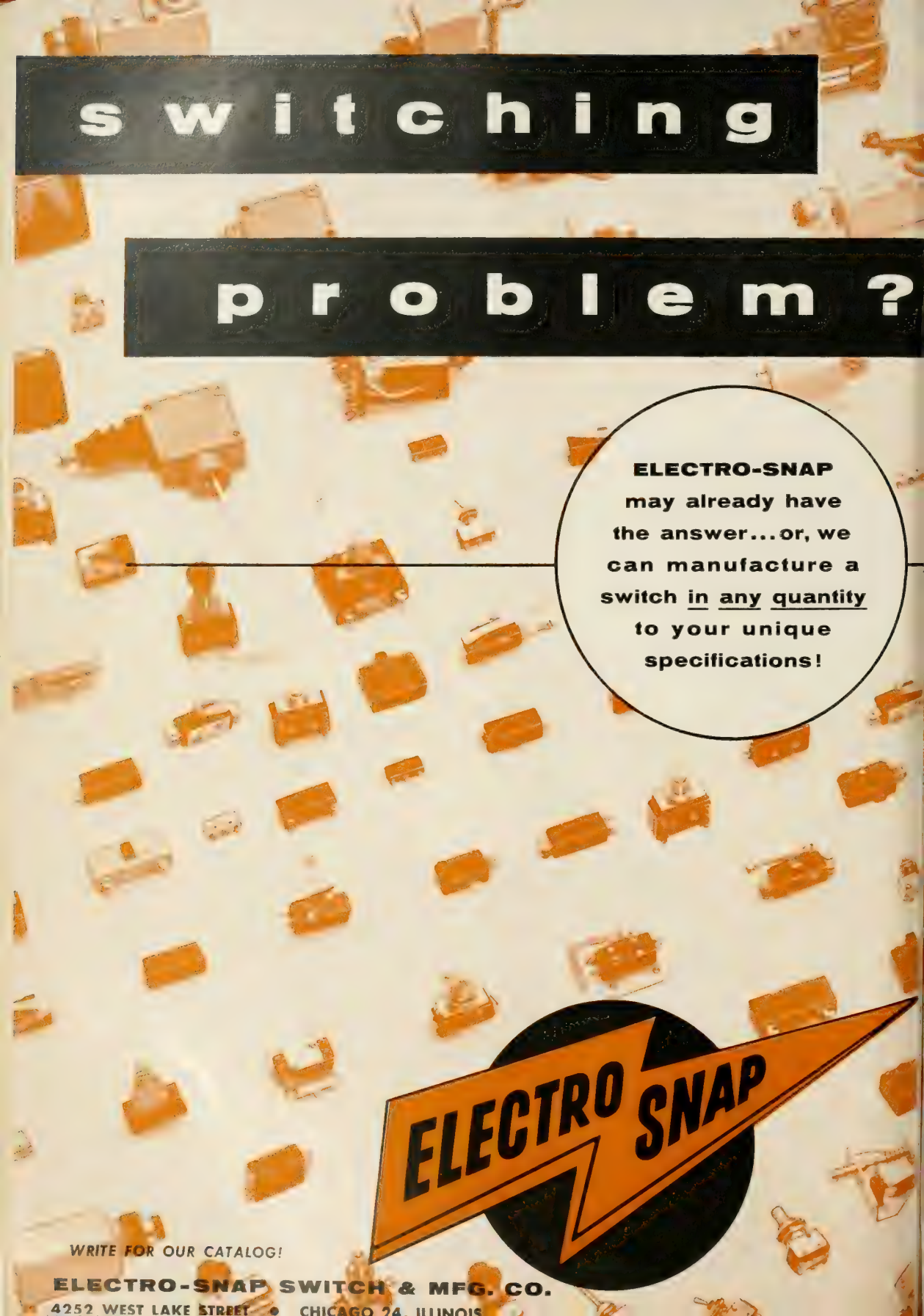
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VOL. 2 NO. 2
FEBRUARY, 1957

missiles and rockets
MAGAZINE OF WORLD ASTRONAUTICS

m/r exclusive:

Russia's Guided Missile Program

By the editors of m/r

THE SOVIET UNION'S arsenal is today bristling with missiles and many of them are in just as an advanced stage of development as their U.S. counterparts. In all phases of missile activity the Russians are making tremendous headway and at the present time have a formidable array of guided weapons in operational status. Of particular significance is the crash program on ICBMs. Present indications are that an ICBM will be available for operational use within two to three years. This is the 5,000 mile range T-3.

While Russia's ICBM is being rushed through the development stage, test firings of an IRBM are in full swing. Several test firings of the T-2, a two stage IRBM with a range of 1,800 miles, take place each week. In operational status is the T-1, an MRBM with a range of 400 miles.

There is a developmental connection between the T-1, the T-2 and the T-3. The T-1 is actually an improved German V-2 (the Russians built about 1,000 V-2s to acquire production know how and for training, and aerodynamic and upper atmosphere research). The T-1 had a powerplant with improved performance, thanks to the use of hotter-burning kerosene in place of alcohol, increasing the chamber pressure, and some weight shaving. The result was that the thrust went up to 77,000 lbs. and the range to 400 miles.

The next stage in Russia's ballistic missile program was to take over the drawing board A4/A9 project and to develop an engine with a thrust of some 254,000 lbs. for a two-stage IRBM, the T-2. From the T-2 came the T-3 ICBM which is being given top priority by the Russians.

Because of the Soviet Unon's insistance that the IRBM and ICBM programs be rushed through, the status of the winged A4 (T-4) is not known. Also unclear is the position of the T-4A, a development of the Saenger antipodal glide bomber.

In the low-range ballistic missile category, the T-7A is still one of the main weapons of the Red Army. This is a solid propellant rocket with nuclear capabilities for tactical use. The T-7A may in fact be approaching obsolescense since versions of it have been made available to the Polish and East German armies for some long time.

In the field of anti-aircraft missiles the Russians are in good shape. Long aware of the threat implied by the existence of large USAF B-29 and B-36 bomber forces, they placed into operation several years ago the M-1 AA missile (Table 2). A higher performance missile in this category is the T-7 which was designed to defend Russian targets against attack from B-47 and B-52 bombers. The T-7 has been in operation for some time and U.S. authorities have confirmed AA missile sites around most large centers. Furthermore, a well-developed radar tracking and warning network stretches all along the Soviet perimeter, from Eastern Europe along the Siberian coasts to the Pacific Ocean.

For low altitude targets the Russians use the T-8 barrage flak rocket system. Two other flak rockets are the T-6 and the GVAI. Both of these probably use double-base solid propellants.

Vast Naval Missile Arsenal

The Soviet Navy is well supplied with missiles. The growing Russian submarine fleet (about 100 under construction and 400-800 in operation) could isolate Europe and allow most of the U.S. and Canada to be hit with existing ballistic rockets. In addition vigorous development of cruise weapons has taken place (Table 3). Another Naval weapon under construction in the Soviet Union is the *Comet* underwater-launched ballistic missile (Table 4) which is likely to have a range of 500-700 miles.

The Soviet Navy is being equipped now with missile ships as well as fast and modern destroyers. Several anti-aircraft missile ships have been sighted in the Baltic and the Pacific together with short and medium range missile-armed attack ships. Naval intelligence now admits that the Soviet fleet is second only to the U.S. in numbers and is growing fast. Russian shipyards are so tied up with naval construction, that all merchant vessels are being built in foreign countries.

In the air-to-air missile field, the standard item is the 3.2-in. rocket which like the U.S. 2.75-in. folding fin aircraft rocket (*Mighty Mouse*) is patented after the German WWII R4M. The M-100 guided aircraft rocket has been radically streamlined and cut in weight. It appears that the new M-100A is about 6-10 feet long with a maximum diameter of 8-10 inches. Equipped with four swept wings aft, the unit is small enough (100-200 lbs.) so that several can be carried by a jet interceptor in addition to a compliment of 3.2-in. aircraft rockets. It is no secret that the USAF is worried enough about these Russian aircraft rockets to give top priority to the development of bomber defense missile systems.

It is not believed that the Russians are relying on manned rocket aircraft to any large extent for the defense of key targets. It is known however, that a VTOL rocket interceptor, the I-2 has been developed. Paper specifications for this aircraft called for an endurance of 7-10 minutes and top

speed well over Mach 1. Armaments specified were 37-mm cannon or 3.2-inch aircraft rockets. The I-2 is a distant relative of Germany's Messerschmitt 163 rocket plane. Impressed with the high performance of the rocket-powered interceptor the Russians tried rocket power to boost the standard power plant of the Yak-21 and the LA-17. This lead in time to the I-1 research rocket aircraft from which the I-2 seems to be a derivative

No Doubt About ICBM

Without stating their sources, several American leaders have revealed details of Russian missiles from time to time. Senator Stuart Symington, on July 21, 1954, told of the Russian attempt to build an intercontinental ballistic missile with a hydrogen warhead of 4,000 to 5,000 mile range. And on May 18, 1955, Rep. Overton Brooks, member of the House Armed Services Committee said "dozens of points in Europe and Asia . . . in a pattern allowing an arc of fire to cover, for instance, the Baltic Sea, are being built for guided missile launching sites."

Senator Symington said: "I don't believe the Soviets are ahead of us in ballistic missiles. I state that they *are* ahead of us in ballistic missiles."

It seems the Russians are at least on a par with us in ICBM rocket engine development. As a matter of fact, it sometimes looks as if the Russians tend to overpower their missiles. Their IRBM, for instance, is powered by a 250,000 pound first-stage rocket plus a 77,000 pound thrust second unit.

On the other hand, their ballistic missiles might lack the accuracy that we claim for our guided weapons; many experts that we have talked with lately are inclined to think the Russians are somewhat behind in guidance and control. Then, again, US engineers who have attended international electronics conferences and seen Russian electronics gear, praise the communists for their advanced all-quality equipment.

Since the Russians took over Germany's Peenemünde with all its gear and hardware, they could resume production of a fabulous weapons system; submersible ballistic missile launchers. With her 600 submarines and this new concept in IRBM warfare Russia has a striking power that will be difficult to match.

Dr. Walter R. Dornberger, former Peenemünde Commandant, brought this concept to the attention of Defense Department officials several years ago, reporting that submersible missile launching platforms to be towed by submarines had been developed by the Germans at Peenemünde. Despite the fact technical reports on these developments were brought to this country a long time ago, no United States project of similar character is known to have been attempted.

The Russians, in fact, are capable of towing huge ballistic rockets 50 feet high in submersible containers to areas hundreds of miles off our coasts. The containers are about 115 feet long with a volume of 14,000 cubic feet. From different locations their missiles could be launched simultaneously against targets on the mainlands. With a range of 1,500 miles—or less—the Red missiles literally could be used against any significant target on the American continent.

Furthermore, this potentiality exists today; the Russians do not necessarily have to wait for completion of their ICBMs to obtain the equivalent firepower. Dr. Dornberger has said he believes the Russians "emphasis on underwater vessels indicates a plan to use submarines offensively, in American waters, quite possibly as tow vessels for missile launchers."

Three slightly different missile-launchers were built by the Germans, and they were all taken over by the Russians, who have had 12 years to complete this weapons system—which, incidently, was almost perfected by the Peenemünde engineers at the end of the war. The launchers, now believed to be mass-produced by the Russians, were first suggested in early 1944 by Dr. Dickmann of the famous Vulkan Werft (Vulcan Works) in Stettin.

Developed in the greatest of se-

Comparison of some typical USSR and USA ballistic missiles



crecy under the code names *Project Swim Vest* and *Project Test Stand 12*, Peenemünde's top scientists, led by Dr. Wernher von Braun, were working on the missile launchers.

Designed for V-2 missiles, the submersible launching platforms were fitted with a control station, tanks for liquid oxygen and alcohol, water ballast tanks and a gyro system to counteract yaw and roll under towing as well as when the launcher was in upright position for firing the missile from its inside. The net weight of the launcher was 70 tons; the missile, its propellants and accessories represented 35 tons. Ballast amounted to 300 tons.

Three launching containers could be towed in submersed position by one submarine at 15 mph. One launcher could be towed at 20 mph. The range was limited only by the fuel supply of the submarine. With specially designed vacuum-insulated tanks the loss of liquid oxygen during transportation was kept as low as 1%.

A series of problems and difficulties were experienced by the Peenemünde engineers during the first tests. In particular, the greatest problem was to keep the launcher stable under transport as well as under firing of the missile. Large rudders activated by the gyro-servo system were used to obtain stability during horizontal operations. Certain hazards were connected with the excessive amount of hot steam that was formed during firing.

The rocket exhaust escaped through funnels, but the terrific heat from the gases caused the water in some of the ballast tanks to boil, forming steam which had to be vented to the asmosphere. Vent systems propellant fumes also were incorporated to minimize the explosion hazards.

It took the Germans—on a wartime crash program basis—only two years to develop the missile launchers, and it seems obvious that the Russians, who took over the equipment, have been able to solve whatever problems the Germans did not have time to solve.

Design criteria for the submarine launchers include an intricate pumping system for the water ballast, as well as a complex electrical system for operation of instrumentation, gyros, pumps,



USA
Redstone
300-500 mi

USSR
T-2 (M-103)
1,500 mi plus

USA
Jupiter?
1,650 mi plus

USA
Titan?
5,000 mi

USSR
T-3 (M-104)
5,000 mi

Model	Mission	Type	Length (ft)	Diameter, Max (ft)	Thrust (lb)	Range (mi)	Status	Notes
T-1 (M-101)	SS	MRBM	50	5.5	77,000	400	P;O	Single-stage, improved A4 (V-2) Lox-kerosene motor Impulse: 4.6 million lb sec
T-2 (M-103)	SS	IRBM	100-125	15	Stage 1: 254,000 Stage 2: 77,000	1,800	P;Q	Two-stage, improved A-4-A9 Stage 2 is T-1 Impulse: 20.4 million lb sec Wt.: 75-85 tons
T-3 (M-104)	SS	ICBM	100-160			5,000	D;T	Two or three stages May use T-1 or T-2 components Wt.: 100-150 tons
T-4 (M-102)	SS	IRGBM	50	5.5	77,000	500-1,000	P	Winged T-1
T-4A		RB				4,000-10,000	D	Two-stage, improved Saenger antipodal bomber Track launched by rocket sled Bomber wt.: 100 tons Impulse: 60.74 million lb sec
T-7A	SS	SRBM	25	2.5	17,600 for 30-60 sec	30-60	P;O	Total launch wt.: about 8,800 lb Truck launched (vertical) HE or nuclear warhead Solid composite propellant

SS: Surface-to-surface
MRBM: Medium-range ballistic missile
IRBM: Intermediate-range ballistic missile
IRGBM: Intermediate-range glide-ballistic missile
ICBM: Intercontinental ballistic missile
RB: Rocket bomber
SRBM: Short-range ballistic missile
P: In production
O: Operational
Q: In qualification tests
T: Test
D: Development

Table I. Russia's ballistic and long-range aerodynamic missiles and rocket weapons, with comments.

lighting inside the launcher and for testing prior to firing. Three technicians can handle the launching of a liquid-propellant ballistic missile.

A conservative estimate indicates it will take less than half an hour to launch a missile after the tow submarine has reached its destination. By remote control from the sub some of the water in the upper ballast tanks will be pumped out, the launcher slowly tilts into vertical position, and only the nose is above the surface.

The technicians, entering from a rubber boat, will open the clam-shaped doors and plug in the electrical connection. A ladder leads down to working platforms and the control room. Gas fumes will be vented to the atmosphere, electrical motors started, and the missile activated and pressurized for fueling and launching.

The technicians will leave the launcher after proper testing of instrumentation and setting of the warhead fuse and guidance. The fire control is handled from inside the submarine. The launcher may be abandoned, or, if circumstances permit, it may be towed back to base or a mother ship and be made ready for use again.

The range of a V-2 missile, when launched from a submersible launcher, was considerably reduced because of the back pressure caused by reversing the rocket exhaust 180° through funnels.

However, with improved rocket engines and lighter components, it is permissible to assume that Russia's T-1 or the *Comet* will be capable of covering hundreds of miles, when fired from a submarine launcher. Significance of this launching method is that the missile may be transported undetected.

Table II. Basic data on Russian research missiles and flight test vehicles.

Model	M-1	T-7	T-8
Length (ft)	14.7	20-25	6-8
Diameter (In)	22	25	4-5
Thrust (lb)	—	17,600	1,000-2,000
Max. Alt. (ft)	50,000	50,000-70,000	25,000
Status	Ob; O	P; O	D; T
Notes	Solid booster Peroxide sustainer Guided Speed: over Mach 1	Solid or liquid booster Acid-amine Sustainer Modified *"Wasserfall"* Wt.: 3-4 tons Guided	Solid propellant Barrage flak

Ob: Obsolete
O: Operational
D: Development
T: Test
P: Production

this launching method is that the missile may be transported undetected.

Inter-service Rivalry?

It appears Chief Marshal of Aviation, N. F. Zhigarev, is Russia's missile czar. Furthermore, it seems obvious the communists have decided to give the Red Air Force the responsibility for all ICBM development. Strangely enough, however, long-range missile launching sites are manned by personnel from both the Army and the Air Force. As a matter of fact, there is more Army personnel involved than Air Force people. One of the reasons behind this concept stems from the fact the Red Army is still "more important" to Russian defense than the Air Force or the Navy. And there could possibly be a question of whether the Air Force —which normally requires skillful personnel—has enough trained field operators for the launching sites. In other words, this situation might change.

While there's no doubt inter-service rivalry is dominant in Russia—as it was in Germany, and as it is this country—all three services have been included IRBMs in their arsenals. The bombardment threat Bulganin referred to last fall—when he stressed that Russia had missiles that could bomb England from East Europe installations—is understood to have been based on Red Army missiles, rather than Navy or Air Force weapons. However, this should not be construed to mean that the Red Air Force and Navy are not capable of attacking Great Britain from far-away launching sites.

All production of missiles in Russia, of course, is under direct Government supervision and sponsorship. There is no private enterprise involved whatever, and even the design competitions among universities and scientific institutions are 'all-government' handled. Yet, there is keen competition between factories and between design outfits. High awards are offered for efficiency, high-production schedules and for all-quality end results. The individual "hero awards" that we hear of so often apply to the missile business as well. Numerous "scientific workers"—which is the Red term for scientists—have struck it rich. Thousands of rubles have been given away each year to individuals working in basic sciences—in particular in the fields of mathematics, physics and chemistry.

The Russians put an enormous emphasis on chemistry, partly because the country has been way behind the rest of the civilized world in this field until recently. Very few synthetic materials had been employed in Russia previously, but thanks to a modern chemical industry, and an advanced one, the communists now are begin-

Model	J-1	J-2	J-3
Powerplant	Pulsejet	Turbojet	Turbojet or Ramjet
Speed	Subsonic	Sonic	Supersonic
Range (Mi)	300	700	1,500-1,800
Status	P;Ob	P;O	P;Q
Notes	Modified V-1 Sub or Ramp Launch Target Use	Ground or Sub Launch	Ground or Sub Launch

P: Production **O:** Operational
Ob: Obsolete **Q:** Qualification testing

Table III. Russian research and flight test vehicles.

Table IV. Russian intermediate-range missiles and upper-air vehicles.

	Model	Type	Length (ft)	Dia. (in)	Range (Mi)	Status	Notes
	T-5	BR				P;O	Artillery & anti-tank. Composite solid propellant rocket.
	ME	G	1.5-2	3.35	1-2	P;O	Recoilless, gun-launched rocket for anti-tank use. May be obsolete: large numbers in satellite nations & middle east.
	T-6	BR		5.2	3-5	P;O	Artillery barrage rocket; projector launched.
Missiles	Comet-1	SS			90-100	P;Q	Sub-launched (undersea) solid propellant rocket.
	Comet-2	SS			500-700	P;D	Sub-launched (undersea) solid propellant rocket.
	M-100A	GAR	6-8	6-10	5	P;Q	Guided air-to-air missile; solid propellant rocket.
	T-3A	Satellite				P;D	3-4 stages. 1 ton payload. Pole-to-pole orbit, 125-1,000 mile. May use T-2 or T-3 hardware.
Research	POL-1		10-15	10		T	Mach 4 test vehicle, two-stages. Stage 1: cluster of 4 solid propellant rockets; stage 2:M-100A type.
	POL-2		20-25	25		T	Single stage rocket similar to T-7A. Geophysical studies from 50-100 miles. Four triangular aft fins, short nose cone; payload 50-100 lb.

BR: Ballistic Rocket **GAR:** Guided aircraft rocket **Q:** Qualification testing
G: Gun **P:** Production **D:** Development
SS: Surface-to-surface **O:** Operational **T:** Testing

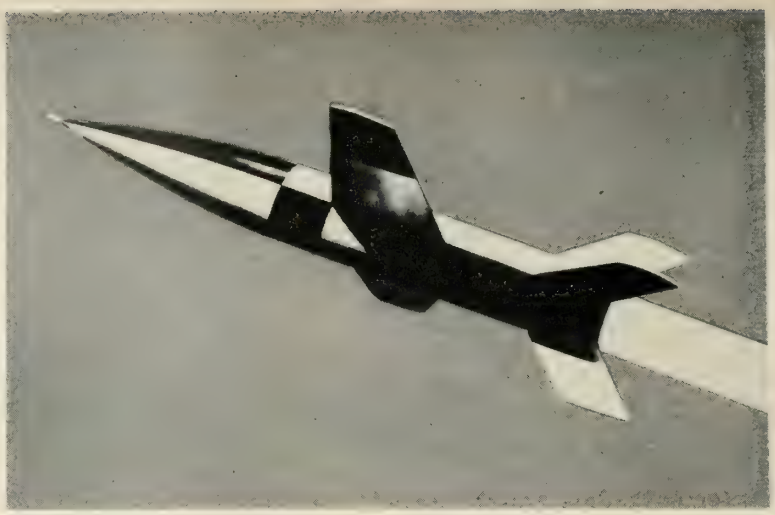
ning to benefit from and apply more and more plastics and resin materials. In turn, the growing chemical industries are yielding more and more to the armed services in terms of useful by-products and know-how for the rocket propulsion industries.

Atomic rockets also are being worked on in the Soviet. There is no report however, on whether they have as yet attempted to construct any nuclear rocket hardware. But since the Russians know we are doing so, one can rest assured that it won't take them long to follow in our footsteps. A report on Red nuclear rocket trends was given in m/r October 1956, and a further analysis will be given in a special issue this spring. Reports on Russian "scientific workers" and Red capabilities in the basic sciences appear in m/r's *special report* appearing on page 61 of this issue.

Dr. Sedov has confirmed that Russian atomic rocket research is progressing at various nuclear research centers throughout the Soviet Union.

A short time ago Russian research engineer G. Nesterenko said that "engines performing on nuclear fuel are of great importance in our contemporary aviation and rocket engineering. Powerful and highly efficient atomic engines will enable us to build rockets that will overcome the gravitational pull of the earth."

Rocket engines with atomic reactors mounted directly in the combustion chambers have been discussed openly in Russia. Active U235 and U238 reactor mass and a graphite neutron inhibitor have been suggested.



This early Russian missile was powered by a liquid rocket engine. Its launching weight was 3,300 lbs. and its top speed was Mach 1.3. It was 15 ft. long and 24 in. in diameter.

Liquid hydrogen will flow through the porous mass, cool the reactor and at the same time acquire tremendous energy. Nesterenko has calculated the exhaust velocity to be in the neighborhood of 22,000 feet per second.

Extensive Research

In the research field the Russians have done considerable work. Animals have been fired to altitudes of 250 miles. A large amount of supersonic and hypersonic aerodynamic and other research work is being carried on both within the Soviet Union and in Russian satellite countries. Poland recently displayed several and multiple stage rockets with Mach 4 capabilities at its Technical Museum. However, the pride and joy of rocket research is the Red satellite effort (See "Soviet Astronautics" in this issue). Even before the Russians announced their satellite intentions, the U.S. was concerned about the implications of the satellite detection centers established in the Soviet Union. Latest word is that the Soviet Union desires to establish a satellite of about one ton in weight.

The whole Russian missile and satellite program is being conducted with the full support of Red Air Force Chief Marshal Zhigarev who believes implicitly in the value of the ICBM. Special Weapons Chief, General A. S. Yakolov is believed to be the missile hardware man in the Soviet Union. Russian rocket efforts appear to be centered in the ZIAM's institute in Moscow. Another important missile development center, particularly for ballistic weapons, is at Khimki near Moscow. Under recent dispersal programs subsidiary development centers have been set up in various points throughout the Soviet Union including some in the Ural Mountain area. Kuibyshev is probably the main center for missile powerplants. Colonel Andrei Kostikov, well known inventor of the Katyusha Salvo guns, has his headquarters in Kuibyshev. The Frunze engine plant in Kuibyshev is producing rocket motors in quantity.

Production of ballistic missiles is scattered over the entire Soviet Union. It is estimated that Russia has the capacity to build some 2,000 monthly. One of the original ballistic missile plants was factory no. 456 in Moscow. Another important ballistic missile plant is in Tomsk. A subsidiary plant of the ZIS automobile concern also is



Chief Marshal of Aviation N. F. Zhigarev, head of the Red Air Force, is an implicit believer in the missile and was largely responsible for convincing the Soviet government of the need to put the ICBM on a "Crash" basis. He is also reported to be encouraging top priority development of space weapons. These top Soviet missile planners were grouped together during the aviation day show at Moscow's Tushino airfield last June. Marshal Zhigarev, Red Air Force chief is speaking. At the left is Marshal Zhukov, Soviet defense minister while Marshal Sokolovski is at the right.

working in the ballistic missile field. One of the more recent developments in the Russian missile production program has been the establishment of plants in the Far East of the country. There was virtually no missile activity east of Lake Baikal until the beginning of this decade. Now, however, there are modern plants at various points in eastern Russia including a big assembly plant at Komsomolsk on the Amur River. The map that accompanies this article indicates the extent of Soviet missile plants and development centers. This map also shows the location of the principle Russian missile bases. The existence of most of the launching bases shown on the map has been confirmed. It also is thought anti-aircraft missile batteries ring all of the most important Russian centers. The ballistic weapon launching bases are located on the Russian perimeter including many points in the far north.

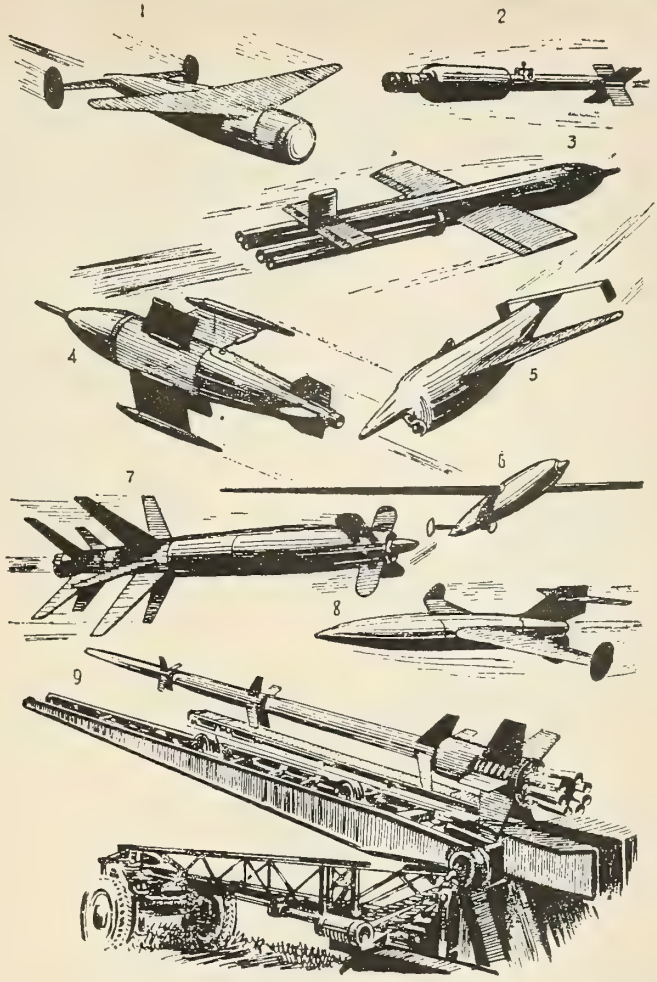
There are also strong indications that Russian missiles have been supplied to the satellite nations. None of these nations have any missile programs of their own although several of them are known to be large scale contractors to the Russian missile industry. East Germany for example, is still an important source of material for missile guide systems although the Russians are rapidly becoming independent in the electronics field.

The Russian dependence on Germany for missile design is long past history. From 1945 to 1950 the Russian effort was almost 100% based on the wartime work in Germany and was carried on by German engineers who were enlisted for duty in missile development in the Soviet Union. From 1950 to 1955 there was a transition with most of the Germans going back to their home land and independent Russian designs taking the place of the German missiles, powerplants and guidance systems. Since 1955 the Russians have been completely independent of German brain power, although most of the current missiles reflect the German thinking that conceived them in their early stages of development. There is some evidence that the Russians are still using Peenemünde missile base in East Germany for certain research projects.

Nonetheless, all evidence indicates that Russia is now on its own in the missile field and is doing well. Missiles enthusiasm abounds among the entire Russian executive class. The apparent attitude of Russia's leaders is to have large quantities of reliable missiles available as quickly as possible. As is the case with most Soviet weapons, the emphasis is on simplicity and reliability.

Although there has been much talk of automation in the Soviet Union —Russia has its own Ministry of Automation in industry—little is known of the current status of many projects. However, it has been reported that some 200 automatic production lines are to be introduced in the course of the current 5 year plan and undoubtedly many of these will be applied to aircraft and missile plants.

Although production methods and techniques are very old fashioned by western standards there is no doubt that the Russians are turning out missiles in quantity. The stock pile of anti-aircraft missiles and IRBMs should certainly be regarded with respect while the imminence of the Russian ICBM is a threat of the first magnitude. The ability of the U.S. to surpass the Russian effort is a key factor in determining the future cost of mankind. ★



Ракетные управляемые снаряды и ракеты на твердом топливе.

1 — управляемый снаряд для поражения наземных целей, запускаемый с самолета; *2* — зенитный ракетный снаряд с радиолокационным взрывателем; *3* — зенитный снаряд, управляемый по радио; *4* и *5* — управляемые снаряды для поражения воздушных целей, запускаемые с самолетов; *6* — управляемый снаряд для действий с самолетов по морским целям; *7* — управляемый зенитный снаряд (с ускорителем); *8* — управляемый снаряд для аэродинамических исследований; *9* — многоступенчатая дальнобойная ракета, установленная на пусковом станке.

Familiar missiles (mostly German) that made up early USSR arsenal. Translation of Russian caption: "Guided rocket missiles and solid-fuel rockets. 1. A guided missile to strike at ground targets, launched from a plane. 2. An anti-aircraft rocket missile with a radiolocating exploder. 3. An anti-aircraft missile guided by radio. 4 and 5. Guided missiles to strike at targets in the air, launched from airplanes. 6. A guided missile launched from airplanes to strike at targets on the sea. 7. A guided anti-aircraft missile (with an accelerator). 8. A guided missile for aerodynamic researches. 9. A many-phased long-range-hitting rocket, set on a launcher."


PEENEMUENDE
RIGA
KOLSKI AREA
NAREV/BUG AREA
KRONSTADT
LENINGRAD
ILMEN AREA
KOLGUEV
MINSK
SMOLENSK
KALININ
KIEV
MOSCOW
RYBINSK
PODBERESYE/KIMRY AREA
KALUGA
KHIMKI
KHARKOV
RAMENSKOYE-ILINSKAYA
KAZAN
SARATOV
STALINGRAD-EAST
KUIBYSHEV
SVERDLOVSK
UFA
URALSKOYE
MAGNITOGORSK
TOMSK
OMSK
UST URT DESERT
NOVOSIBIRSK
KARA KUMY DESERT
TASHKENT


SEVERNAYA ZEMIYA
NEW SIBERIAN ISLANDS
ANADYR AREA
CAPE CHEIYUSKIN AREA
TAIMYR AREA
CAPE NORVIK
KHATANGA
MILKOVO
NORTH SAKHALIN AREA
NIKOLAEVSK
TOROKO
OTOMARI
KOMSOMOLSK
IRKUTSK
LEGEND
LAUNCHING BASES
MISSILE PLANTS
MISSILE SCHOOLS
MISSILE TEST CENTERS
ANTI-AIRCRAFT ROCKET PLANTS
MISSILE DEVELOPMENT CENTERS
MISSILE ENGINE DEVELOPMENT CENTERS

U.S. Military Leaders Warn of Red Danger

Reds Put Emphasis on Rocket Power, Long-Range Missiles, Subs

It was a coincidence that while the editors of m/r were winding up their research for this issue, three U.S. military leaders, Army Secretary Wilber M. Brucker, Assistant Secretary of the Navy for Air Garrison Norton, and Western Development Division Chief General Bernard A. Schriever presented significant speeches on the subject of the increasing danger of the Red war machine.

Not Just Plain Talk

Such speeches frequently have been given by military and political leaders in this country during the last few years. On rare occasions only have any such leaders stood up and told the American public what we have achieved in terms of actual hardware and in terms of the technical advancements that you can put your finger on. It was gratifying, therefore, to hear General Ben Schriever present his speech recently before the Institute of Aeronautical Sciences on guided missile research and development in the United States Air Force, for the WDD Chief plainly stated we now have a broad foundation for United States leadership in ballistic missiles. This is based on the fact, according to the General, that all major milestones for the *Thor, Atlas* and *Titan* development program have to date been passed on schedule.

One factor that has often been overlooked in the missle race was stated by General Schriever:

"There has been much speculation as to whether we or the Soviets will have bigger and better ballistic missiles. This is somewhat like weighing the chances of the participants in an automobile race solely on the basis of their cars instead of also considering the training and experience of the drivers, the reliability of their equipment, the support which they receive in the pits, and similar factors.

"A broad foundation has been created for U.S. leadership in ballistic missiles—a foundation which may also serve to assure U.S. leadership in future space technology.



Air Force WDD Chief
General Bernard Schriever

The Ultimate Respect

"However, the data which would serve best to prove these points convincingly cannot be told for security reasons because those are the very data on which our leadership rests. Suffice it to say that the broad breath and great depth of the ballistic missile program assure ultimate achievement of our goal, without depending on one success or facing defeat on account of one failure.

"There is one final question—what will we have achieved when we reach our goal—when ICBM's and IRBM's have become reliable, operational weapon systems produced in quantity? Paradoxically, the best we can hope for is that we will never have to use these weapons; that our ballistic missile capability will be so highly respected by all potential aggressors as to indefinitely deter them from attacking us.

"This should not imply that the ICBM or IRBM are "ultimate weapons" as they are frequently called. Nor will the ballistic missile replace the manned intercontinental bomber. But it will undoubtedly become one of the most potent and convincing arms in our arsenal of strategic weapon systems."

Army's Brucker: Soviet Leaders Fool Themselves

"America can hope to lead the world to a just and honorable peace only if we all remain staunchly true in every sphere of activity to the great moral concepts upon which this Nation was founded—the lofty ideals which have been the driving force behind its advancement through the years to a



Secretary of the Army,
The Honorable Wilber M. Brucker

position of preeminent power and prestige. Uncompromising Americanism is the only solid foundation upon which we can stand to do battle with the communist monster.

"We have had ample warning of of the danger we now face. For a short time not many months ago, numerous people throughout the world, including some in our own land,—imagined they saw reason to believe that the leaders of the communist conspiracy had experienced a change of heart—that they had abandoned armed aggression as a means to attain their ends, and honestly sought peaceful resolution of the world's differences. Dead Stalin was denounced by his confederates. Sweet words and disarming smiles briefly replaced his intransigent hostility to the Free World.

"How utterly this phantasy of Soviet 'reformation' has been shattered. The merciless butchery of liberty in Hungary, the open efforts of the Soviet Union to obtain a military foothold in the vital Middle East, which Russia has coveted for centuries, and the increasingly brazen attempts of the leaders of the Kremlin to stir up dissention wherever possible, and exploit unrest in order to extend their power have served notice on all free nations that freedom everywhere is in greater jeopardy today than it has been for many years.

"In addition to the testimony of evil deeds, we have Khrushchev's strident boast to the West: 'History is on our side. We will bury you!' Only a week ago,—in virtually reconsecrating Stalin as the patron saint of militant communist imperialism—Khrushchev reiterated his warning that the Soviet Union will contribute in every way it can to the death of the Free World. How could any threat be more plain?"

"Soviet leaders are fooling no one but themselves when they call upon history to justify their trust in the ultimate triumph of the ideologically bankrupt communist tyranny. If Khrushchev and his fellow conspirators read the record straight, they must realize that no despot can take comfort in history. The verdict of time has always vindicated the leaders who have served the cause of freedom and human justice—not the Caesars and Hitlers who have ridden the chariots of oppression over the broken bodies of millions."

(These are direct quotes from a speech given by the Honorable Wilber M. Brucker before the Sertoma Club of Washington January 25.)

Navy's Norton Stresses Red Sub Threat



Assistant Secretary Norton

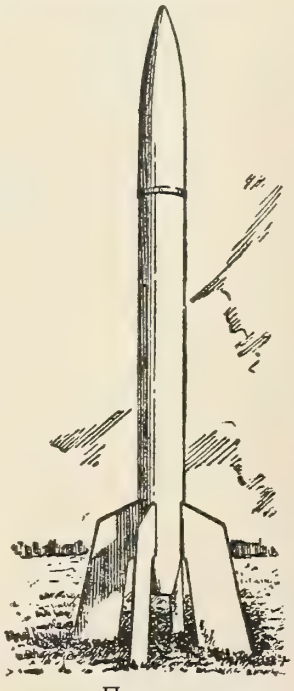
"As the opposing major powers round out their stockpiles of atomic weapons, I believe it has become increasingly clear to people throughout the world that all-out nuclear war is wholly irrational. We know there can be no winner of such a war. At the so-called Summit Conference the leaders of the Soviet Union gave evidence that they too had come to this conclusion. In so doing they must have discounted, or at least degraded, what hitherto has been considered to be a dangerous military advantage of totalitarian nations over free nations, namely the willingness to make a surprise nuclear attack.

"Now this is not to suggest that we should lower our guard against surprise attack. Well dispersed bomber and missile forces, both land and sea-launched, will continue to be the major deterrent against such attack. What I do suggest is that any Nation seeking to achieve its objectives by military action must develop and employ *alternatives* to all-out nuclear warfare. We know from painful experience that the Soviets have demonstrated great ingenuity and long-range purpose in doing just that, from the construction of by far the largest submarine fleet the world has ever known, to the development of new techniques for armed subversion and infiltration.

"Faced as we are with the Soviet strategy, there is no doubt whatever that we, the leading free nation, must speedily develop alternatives to the nuclear capability upon which we have concentrated so much of our manpower, time, and money. We must place some limitation on it to maintain a sound economy, and at the same time have enough in the budget to provide the flexible, versatile forces that can readily respond to the more likely types of limited aggression and hostilities. If we fail to do this, we shall immobilize ourselves in an era of renewed Soviet aggression.

"Indeed, we must develop alternatives on the political and economic, as well as on the military fronts. Immediately after World War II, I stepped from the Navy into the Department of State, and did a tour of duty as an Assistant Secretary of State. No one is more keenly aware than I, that these other two fronts share equal importance with the military, in the development of our foreign policy. I am not going to discuss political and economic alternatives today. But when it comes to military alternatives, I suggest that you keep your eyes on our new Navy."

(These are direct quotes from a speech given by the Honorable Garrison Norton, Assistant Secretary of the Navy for Air, at an Aviation Writers Association meeting in Washington January 25.)



Первая советская ракета с жидкостно-реактивным двигателем, сконструированная М. К. Тихонравовым.

This Russian rocket was tested in 1933, according to the Russian publication from which the drawing is taken. It was designed and built by engineer M. K. Tikhonravov. According to the Russians it "ascended to a great altitude, changed its direction and flew horizontally for some time before descending to earth." Liquid oxygen was used.

MISSILES & RUBLES

If the Red missile arsenal doesn't match that of the U.S., it's not because of a lack of rubles and what they represent. In terms of economic capacity, the Union of Soviet Socialist Republics has what it takes. The only real doubt is in the level of her applied technology.

Setting aside politics for a minute and a top talent as a global trouble-maker, after one of the most astounding economic growths in history, the U.S.S.R. stands second only to the U.S. in basic industrial capacity.

Add the dictatorship's known ability to concentrate effort where it does the most good, and Russia becomes an adversary of note.

And vital is the fact that Russia could not survive a long, old-fashioned World War II kind of scrap either politically or economically. Her people, like the Satellite populations, are restive. Economically, she can handle the current state of semi-war. But with virtually no consumer goods industry, she's got no give for expansion to all-out effort.

Short-War Concept

Not only does Russia have an interest in missiles as the lastest in weaponry, but the long-range nuclear ballistic missile is the weapon of the short war, or so it's said. And a short war is the only kind of war Russia could hope to win.

Last summer, for the first time in 17 years, the Central Statistical Administration of the Council of Ministers USSR—Red equivalent of the U.S. Census Bureau—published some hard figures on the Soviet economy. The *New York Times*' Dr. Harry Schwartz has compiled an analysis of these figures into a "Statistical Handbook of the USSR ($3, National Industrial Conference Board, 460 Park Ave., N. Y. 22, N.Y.). Careful checking indicates they are at least in the same ball park with reality. They form this basis for this m/r appraisal.

Prior to the 1913 revolution, Russia was a feudal power, with only 17.6% of the population being urban; 82.4%, rural. Today the break is 43.4% to 56.6% respectively. With this shift from the farms to the cities has come massive industrialization — industrialization with gays, true, but not where they hinder Red munitions output. As in the days of the Czars, the mass of the people still come last, the state first.

Since 1913, consumer goods output has gone up 1,000%. So, the average Russian is, in fact, a little better off. But the output of goods for production is up 5,200%.

Spurred on by World War II and open Cold War with the West, the greatest expansion of the Soviet economy has occurred since 1940. The population has risen only 5%, 191.7 million to 200.2 million as of April, 1956. But by 1955 basic industrial output had jumped in most cases over 200% in 15 years. The sixth and current five-year plan calls for 1960 totals to be 50%-to-150% up again. Table on this page gives some actual figures.

Notably, nothing on defense related industries, such as non-ferrous metals, aircraft, electronics, etc., has been released. However, it's known that munitions come only after basic industry in the concentration of Red effort.

With basic production now in hand, Russia is turning her attention to standards of technological research and development. In the missile business, this is significant. For the pounds of actual hardware in a missile are few. It's how they're arranged that counts.

In this connection, the number of "specialists with higher education" has jumped from 908,000 in 1941 to 2,340,000 in 1956. Of these, engineers are up from 290,000 to 586,000.

While shortcomings of Red technology are still apparent in many fields, they are least obvious in heavy industry and munitions. The heaviest presses and largest milling machines are still claimed by Russia. And while her claim to operational IRBM's has yet to be proved, her abilities in the demanding arts of jet aircraft and atomic power are evident.

Additional figures quoted support this appraisal. For example, industrial production workers have increased from 8-million in 1932 to 17.4 mililon in 1955. The availability (not output) of metal-cutting machine tools has increased from 710,000 at the end of 1940 to 1,760,000 a year ago; press and forging equipment, from 119,000 to 365,000. And while are not truly quantitative, since they don't say what kinds of tools, U.S. technicians who have seen Soviet equipment respect it.

And in the strange ways of the Communist statistician, this for what it's worth: In 1950, 555,000 people offered 1,241,000 of which 655,000 were adopted in production. In 1955 the figures were 1,138,000, 2,080,000 and 1,160,000 respectively.

Reds Have Capability

Though none of this adds up specifically to "missiles in production," even in exaggeration the figures leave no doubts as to Russia's basic economic capacity to make missiles. Aided by a lot of stealing, borrowing and extrapolating from the West, plus a growing volume of new development on their own, Red technical ability is moving up on the West in more and more fields. In a few words, if the Soviet theoretician knows how to make an ICBM, Soviet industry can carry his paperwork to the operational stage. There are persistant reports that this is being done.

Soviet Basic Industrial Production
(in units unless otherwise stated)

	1913	1940	1955	1960
Pig Iron (1000 tons)	4,200	14,900	33,300	53,000
Steel (1000 tons)	4,200	18,300	45,300	68,300
Rolled Metal (1000 tons) ..	3,500	13,100	35,300	52,700
Coal (1000 tons)	29,100	165,900	391,000	593,000
Petroleum (1000 tons)	9,200	31,100	70,800	135,000
Elec. Power (million kwh) .	1,900	48,300	170,100	320,000
Metal-cutting				
Machine Tolls	1,500	58,400	117,800	200,000
Large, heavy & unique ...	....	212	3,541	not said
Press & Forging Machines ..	....	4,700	15,900	25,800
Motor vehicles*	....	145,400	445,300	650,000

* This includes both trucks and passenger cars and was included as typical of the low proportion of effort going into consumer durables.

Soviet Astronautics

Red IGY Satellite to be Launched by Help of ICBM Hardware

By Alfred J. Zaehringer

Though the Russians admit they are still far from launching a manned space vehicle, they will almost certainly launch an artificial satellite durin the International Geophysical Year. The best conclusion that can be reached on the basis of the sparse amount of information available to the West is that they are not bluffing. Though it may not get "up there" as soon as the *Vanguard,* when the Red Satellite does settle into its orbit, it may well be heavier—and more exclusive.

The satellite the Russians talk about will probably have recording and fast play-back equipment (see m/r's personal report, this issue) and may thus transmit its measurement only while passing over the Soviet receiving station.

In more detail, this much seems apparent:

——the Russian satellite will be quite similar to Dr. S. Fred Singer's *Mouse* vehicle, making magnetic as well as more conventional measurements.

——It will have a polar orbit, thus enabling it to cover all latitudes and longitudes "while the earth rotates beneath it."

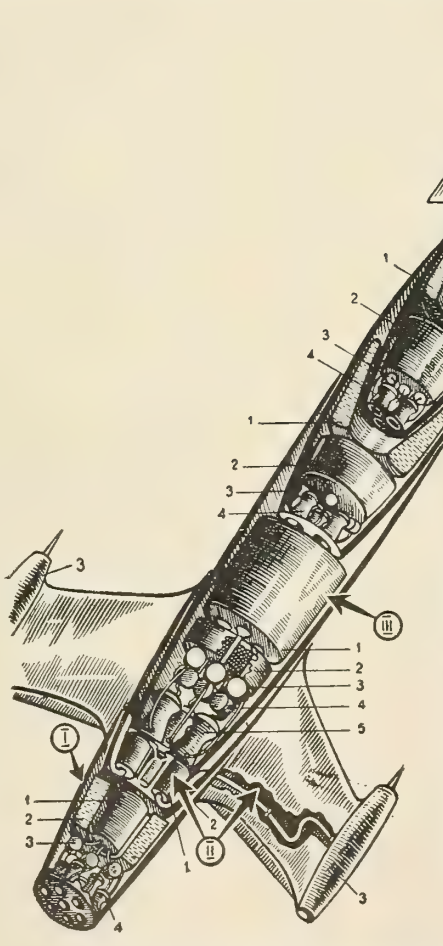
——It will weigh a minimum of 50 pounds, perhaps as much as 100.

——It will be placed in its orbit by a rocket system that is basically the Soviet Intercontinental Ballistic Missile.

Professor K. Stanyukovich, Doctor of Technical Sciences, in Krasnaya Zvezda, August 7, 1955 (as translated by the Rand Corp. for the USAF) wrote as follows:

"The satellite can attain the necessary velocity with the aid of a two-stage rocket . . . if launched at an angle of 45°. When the rocket attains an altitude of 300-to-500 kilometers . . . at the highest point of the trajectory, there must be an explosion which will cast off the sphere to the side of the circumference of the earth with a velocity of eight kilometers per second and thereby convert it into a satellite. Calculations of Soviet scientists, and in particular of Professor G. I. Pokrovski, show that in order to impart the necessary velocity to the sphere, the weight of the explosive charge must be ten times as great as the weight of the satellite itself. Between the satellite and the explosive there must be some inert mass which protects the satellite from the action of the explosion. This mass can be a compressed gas. Undoubtedly, there also can be another, better version of launching the satellite."

That was in 1955. Since then "better versions of launching the satellite" apparently have been developed. This earlier concept estimated that the satellite would revolve around the earth for "several days" before being "retarded



Космическая ракета.
I. Стартовая ступень с жидкостно-реактивным двигателем (ЖРД): **1** — бак с горючим; **2** — бак с окислителем; **3** — турбонасосные агрегаты (ТНА); **4** — камеры сгорания.
II. Ступень с воздушно-реактивным двигателем (ВРД): **1** — баллон со сжатым воздухом; **2** — баки с горючим; **3** — прямоточные ВРД.
III. Ступень с атомным двигателем: **1** — бак с рабочим телом; **2** — ядерное горючее; **3** — ТНА; **4** — устройство для подачи ядерного горючего; **5** — камеры.
IV. Ступень с ЖРД: **1** — бак с горючим; **2** — бак с окислителем; **3** — ТНА; **4** — камеры.
V. Ступень с ЖРД: **1** — бак с горючим; **2** — бак с окислителем; **3** — ТНА; **4** — камеры.
VI. Ступень с ЖРД: **1** — топливо; **2** — окислитель; **3** — ТНА; **4** — камера; **5** — кабина экипажа.

Russian sketch of six-stage atomic cosmic rocket showing:
I. Starting stage with liquid jet engine: 1) fuel tank; 2) oxidizer tank; 3) turbine pump unit; 4) combustion chamber. II. Stage with air-jet engine: 1) compressed air cylinder; 2) fuel tank; 3) direct-flow air-jet engine. III. Stage with atomic engine: 1) tank with working substance; 2) nuclear fuel; 3) turbine pump unit; 4) device for feeding nuclear fuel; 5) chamber. IV. Stage with liquid rocket engine: 1) fuel tank; 2) oxidizer tank; 3) turbine pump unit; 4) chamber. V. Stage with liquid rocket engine: 1) fuel tank; 2) oxidizer tank; 3) turbine pump unit; 4) chamber. VI. Stage with liquid rocket engine: 1) fuel; 2) oxidizer; 3) turbine pump unit; 4) chamber; 5) crew cabin.



Soviet Astronaut Sedov

by the small amount of atmosphere which still exists at this altitude, (when) it will begin to move in a spiral. At an altitude on the order of 100 km. it will begin to shine and gradually evaporate."

The history of Soviet astronautics extends back before the turn of the 20th Century and first took coherent formalized form in 1903 with the publication of a paper by K. E. Tsiolkovskii entitled "Investigation of World Spaces by Reactive Instruments." Since then the study and contemplation of astronautics has been a respectable occupation. He worked on a concept of "cosmic" rocket planes. Another Soviet pioneer in this field, F. A. Tsauder, suggested that step rockets should be so constructed that the actual structure of each stage itself could be processed and consumed as fuel, thus putting dead weight to practical use.

Though it seems pretty obvious that the Russians do not yet have any substantial hardware ready on the firing mat for launching a manned satellite or moon-circling vehicle, the Russians have been thinking about this sort of thing for a long time; one of their forte's appears to be the ability to design and construct massive thrust engines; and in the race for weapons supremacy now being waged between East and West, the advantages of operational space vehicles is obvious.

Furthermore, the Soviet ability to concentrate massive technological and industrial effort without having to answer to the electorate or to consider the needs and wishes of the general consuming public, make the Soviet a place to watch in this connection.

Russian astronautical efforts are now vested in three main groups. There is the purely scientific USSR Academy of Sciences which recently formed the Commission on Interplanetary Communications (Space Flight). The Soviet satellite project operates under this commission. Thus, the project, and its organization, has official government sanction and is on a high level. The respectability of astronautics has been increased by the Tsiolkovskii Gold Medal for Astronautics to be awarded to outstanding scientists.

In the middle is the Chkalov Central Aero Club. With headquarters in Moscow, this group is composed of scientists and engineers. The Austronautics Section, recently formed, also belies the official credulence being given to space flight. Presumably, like its analog, the American Rocket Society, Chkalov is a professional society. However, in all probability, it is a buffer group between official sanction and the hardware groups.

Representing hardware are the armed forces of the USSR. It is here that implementation of astronautical efforts becomes less evident. The Reds employ such heavy security here that all references to rockets, for example, are either: very general, foreign developments, or ancient history. Penetrating this veil has been difficult but not impossible. Authoritative sources have outlined a vast rocket and missile effort comparable in magnitude to American developments. Firing an 1,800-mile range IRBM and work on an ICBM are only two indications that the Soviets are near satellite vehicle hardware.

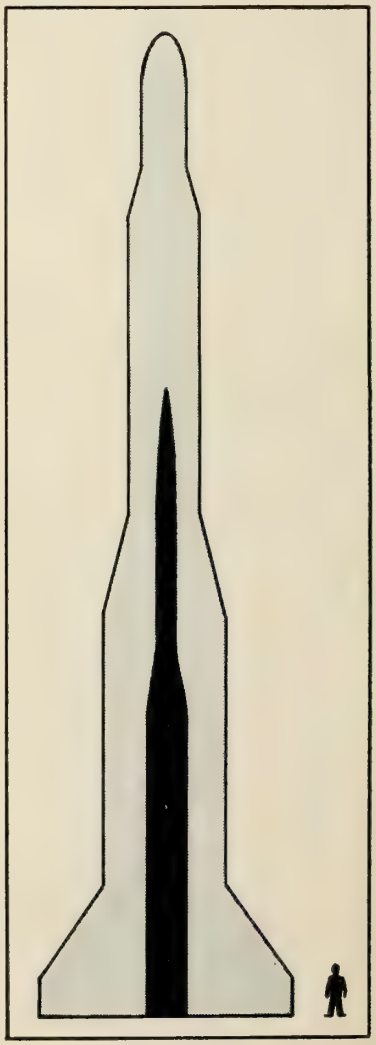
Even more nebulous are references to a Soviet moon project. One version was described in *Pionerskaya Pravda* in 1951. M. K. Tikhonravov of the Academy of Artillery Sciences mentions a 1000-ton circumlunar rocket. The newspaper *Krasnii Flor* (Red Fleet) was later to have said that this rocket was designed to develop 350 million hp and would be 196 feet long, with a diameter of 49 ft. Probably more in keeping with rocket hardware is the description of a one-way moon rocket by Yu. S. Khlebtsevich. The interesting feature of this proposal (first described in *Nauk i Zhizn*) is a "tankette" robot laboratory for exploring the lunar surface.

In checking through Soviet references to space flight, though they sometimes give credit when they quote foreign data and ideas—which is often—it is not always easy to determine just when they are citing or claiming to cite original Russian thinking. However, a quick rundown of some of the propositions they espouse, whether their own or borrowed, gives a pretty good idea of the way they think.

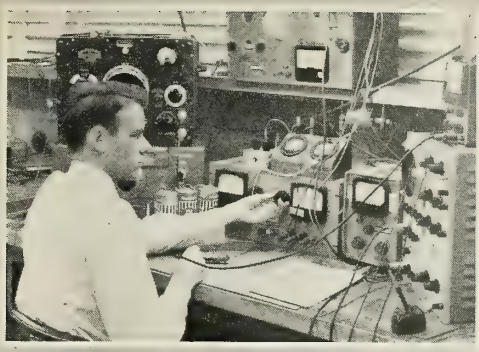
A. G. Karpenko and G. A. Skuridin, writing on the "Contemporary Problems of Cosmic Flights," quote E. Stuhlinger's electrical propulsion system utilizing cesium and rubidium as fuel. He also says that "The problem of utilizing gravitational fields created by the Earth, the Sun, and the planets is absolutely essential for cosmonautics. The fact is that the correct choice of the direction of flight, taking gravitational forces into account, can ensure the ship's motion in space along complex trajectories without significant expenditure of fuel.

Elsewhere in the Rand Corporations "Casebook on Soviet Astronautics" the statement is made that while radar will be useful in measuring distances to and speed by nearby bodies, the space vehicle's velocity relative to more distant bodies may be bettered measured by means of "a special interferometer, which determines the Doppler shift of individual spectral lines.

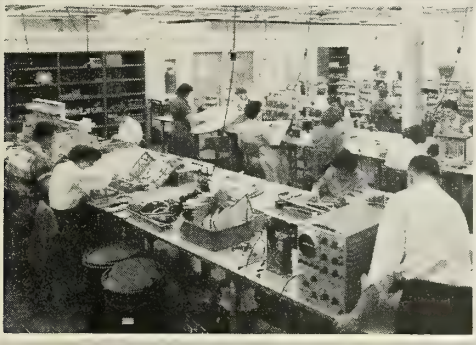
Soviet writers also suggest that a space ship on returning to earth will begin atmospheric braking of its speed at an altitude of less than 200 km. "The ship will describe around the earth a number of decreasing ellipses whose perigrees are submerged in the earth's atmosphere."



Soviet's IGY satellite is a gigantic project, as seen in view of the superimposed Vanguard.



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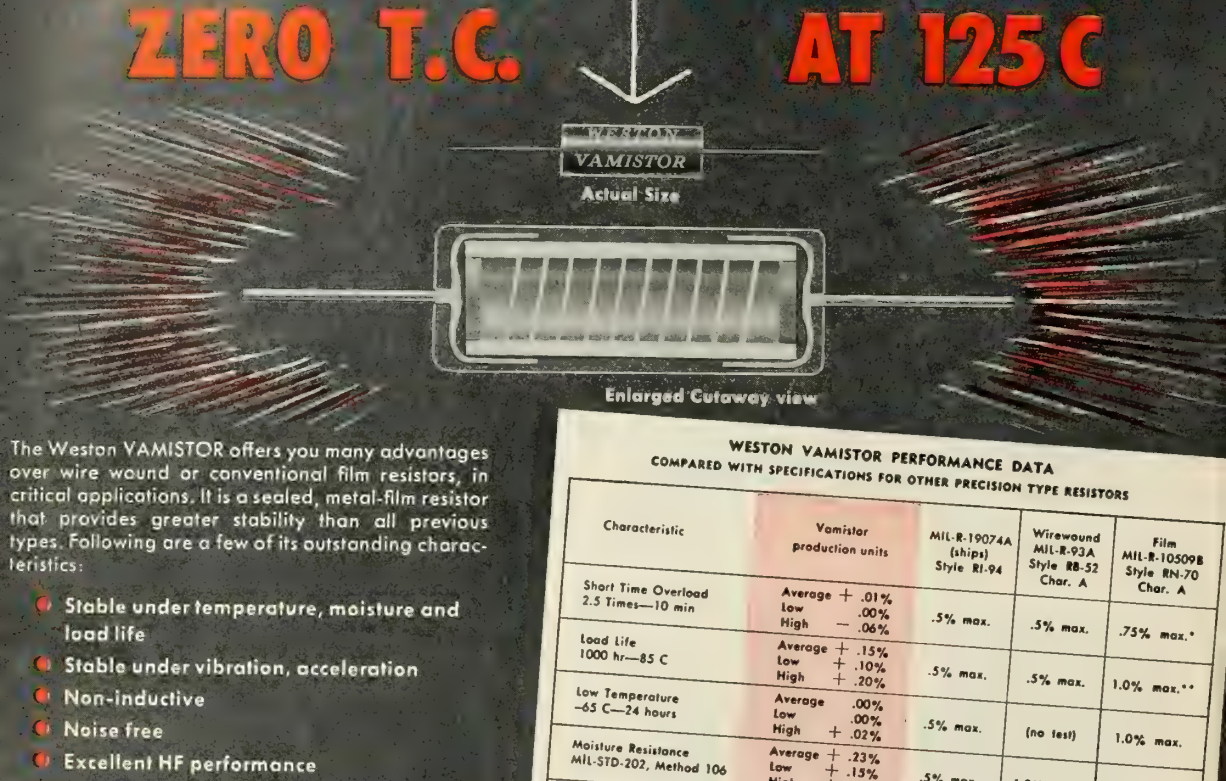
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Load Life 1000 hr—85 C	Average + .15% Low + .10% High + .20%	.5% max.	.5% max.	1.0% max.**
Low Temperature −65 C—24 hours	Average .00% Low .00% High + .02%	.5% max.	(no test)	1.0% max.
Moisture Resistance MIL-STD-202, Method 106	Average + .23% Low + .15% High + .36%	.5% max.	1.0% max.	3.0% max.
Salt Water Immersion 0 to 85 C—5 cycles	Average − .04% Low + .02% High − .10%	.5% max.	.5% max.***	(no test)
Temperature Cycle −55 to 85 C—5 cycles	Average + .04% Low + .02% High + .07%	.2% max.	.2% max.	1.0% max.
Insulation Resistance 100 v d-c	Greater than 10,000 megohms	100 megohms min.	50 megohms min.	10,000 megohms min.
Dielectric Strength 900 v rms—1 minute	Below measurable value—all samples	.05% max.	.05% max.	.5% max.
Terminal Strength		.5% max.	(no limit)	.5% max.
Effect of Solder		.5% max.	(no test)	.5% max.

*MIL-R-10509B test 2.5 times—5 seconds **MIL-R-10509B test at 70 C ambient
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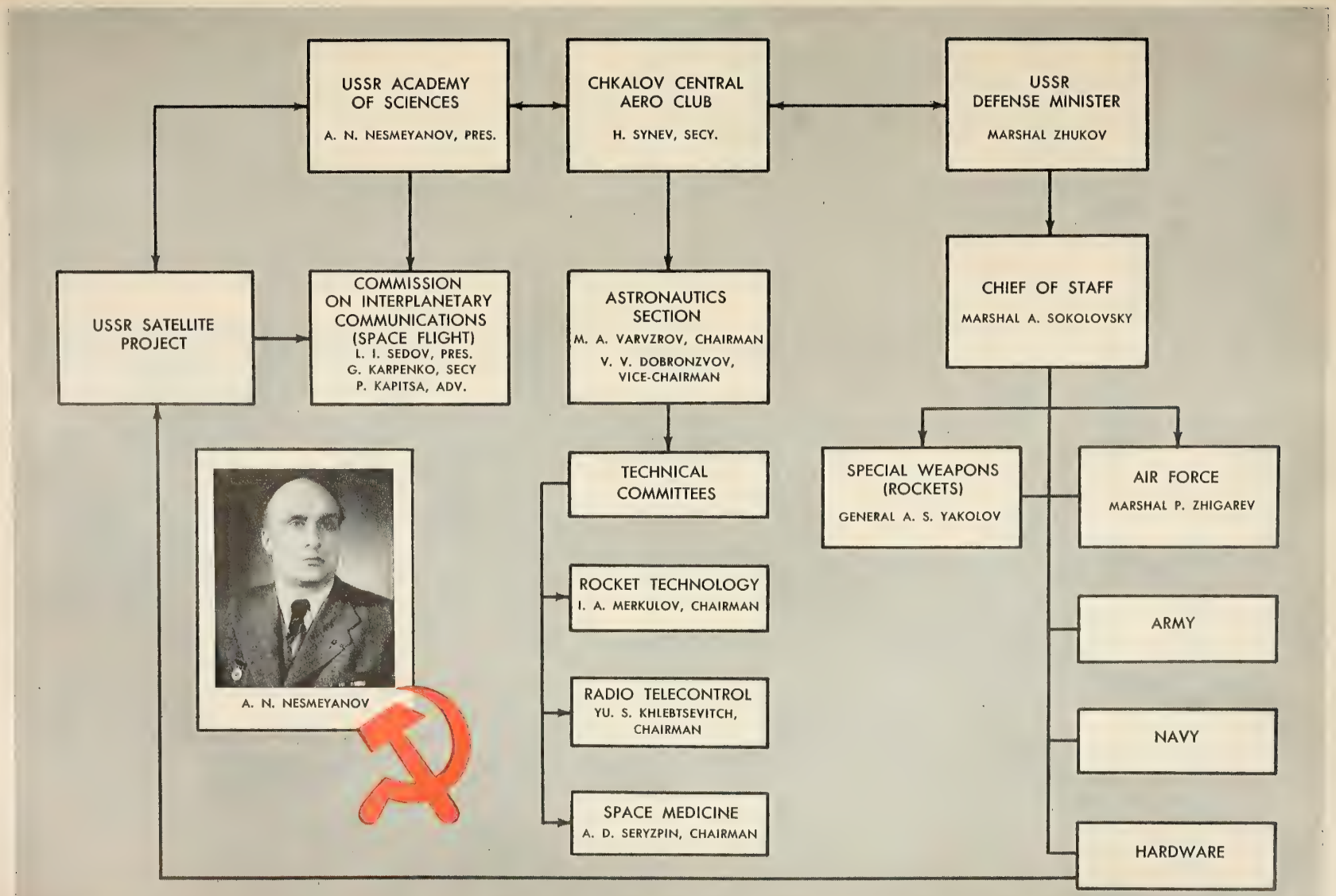
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Presented for the first time in the U. S.: organizational chart of USSR's IGY satellite program.

Rockets Change Modern Army Doctrine

. . . and the Soviets know it

By Major General J. B. Medaris

Commanding General, Army Ballistic Missile Agency

ARMY tatical doctrines are being rewritten as rockets and guided missiles expand the range and increase the lethality of Army striking power. Other nations, including the Soviet Union, have added rockets to their military arsenals and are exploring the potentialities of long-range guided missiles.

Full impact of the revolutionary rocket weapons systems cannot be evaluated at this juncture. But some of the immediate potentialities may be appraised. To do so requires an understanding of Army field organization. Relating this to Korean terrain, which has become so familiar to so many Americans, may be helpful.

Military operations conducted on a large scale normally involve three distinctly separate but mutually inter-dependent commands. In Korea, a Base Command was developed around Pusan on the southern tip of the peninsula. From its boundary north to the combat zone, and spread across the waist of Korea, was the Communications Zone. The Eighth US Army Combat Area extended northward from Inchon and Suwon to the Demilitarized Zone.

Within the Base Command the Army accumulated substantial quantities of supplies: food, clothing, housing materials, automotive equipment and parts, tracked vehicles and all the other paraphernalia required by troops in the field. Smaller reserves of these stocks were maintained in depots in the Communications Zone closer to the using units. In the Eighth Army area to the north, centered on Seoul, were the corps and divisions—the Army's fighting arms.

As operations proceeded, supplies were moved in successive stages; first from the Zone of the Interior or from bases in Japan to Pusan; thence in smaller quantities from Base Command into the Communications Zone, known to thousands of service personnel as KCOMZ; thence to the combat area.

Ground commanders in Eighth Army were responsible to protect their sources of supplies in the rear areas and to defend the Republic of Korea from enemy invasion. To defend their positions they depended upon organic firepower such as the light Infantry weapons, heavy mortars, howitzers and artillery. For far-reaching firepower they called upon the Air Force, occupying fighter and bomber strips to their rear, or the Navy operating planes from carriers off the Korean coast. This type of unified striking power is familiar to any World War II veteran who saw active service in Europe or the Far East.



General J. B. Medaris and Chief of Staff Admiral Arthur Radford at Redstone Arsenal.

While it effectively checked the enemy in Korea, and contributed to the victory of World War II, certain disadvantages inherent in the weaponry involved have long been recognized within the Army. The ground commander was restricted in maneuver within rather narrow limits. His heaviest guns could hit targets less than 25 miles away. Thus he was compelled to keep his artillery well forward. If the enemy's artillery possessed equal range, as must be anticipated, it meant that artillery emplacements were well within striking distance of the foe's counter fire.

We have not yet witnessed the atomic battlefield and hope that we shall never experience it. But the shape of things which might come can be pretty well determined. It would mean vastly greater depth in the combat area, avoiding concentrations of men and materiel, and requiring maximum maneuverability. One can well appreciate, therefore, that if forced to depend upon conventional artillery, the ground commander would present inviting targets to an enemy with atomic capability.

Problems of maneuver and exposure have long since pressed for solution. Exposure, that is, not only of materiel such as weapons and ammunition, armor and transport, but of the troops which serve them and the supporting units which repair, replace and maintain weapons, communications, and satisfy the human needs of the combat units.

Any Army commander well knows that the efficiency of the individual

soldier under stress of combat will inevitably suffer from prolonged exposure to enemy guns.

The role of aircraft in our Army's attempts to resolve these problems is well understood. Organic Army aviation reached new highs in performance during the Korean fighting by spotting targets, checking fire, evacuating wounded, and supplying hard-to-reach points. The bomber and fighter planes rewrote history in World War II and rendered yeoman service in Korea.

But the plane, as a delivery system, has admitted shortcomings. It cannot yet operate in adverse weather, its effectiveness at night is somewhat limited. It is a highly expensive fighting machine to build and maintain. Its crew is normally exposed for relatively long periods of time over hostile territory. What's more, at the higher speeds required to provide more protection to plane and crew, it becomes a less dependable bombing platform under such terrain conditions as were encountered in Korea.

It was to overcome these limitations that the rocket and the guided missile were brought to their present state of effectiveness by the Army with the constant assistance of industry and research agencies. What the guided missile is capable of may be gauged if we again relate it to the Korean situation.

Our ground commanders of the future may call upon such weapons as the *Dart, Corporal, Little John* and *Honest John* for tactical purposes, for greater range and lethality. (Instead of measuring his organic firepower in terms of conventional artillery, he now possesses the means to strike at targets three times as far away.)

Given such a weapon as the medium range *Redstone* ballistic guided missile, soon to become operational, the ground commander can locate much greater firepower at distances many miles behind his lines. From Taegu, let us say, he could launch *Redstone* missiles under any weather conditions, at any time, against targets along and behind the enemy's lines. These missiles would carry warheads with lethality equal to the heavier bombs. They would travel at supersonic speed, subject only to automatic control and guidance carried on board, and could not be intercepted by any known counter measures.

Within the realm of possibility, based upon firm achievements in the art, missiles of greater range will also be available. With these, firepower equal to the Redstone's payload could be directed at hostile targets from deep inside the Base Command.

Still more distant bases may be utilized when our intermediate range ballistic missiles, now under development, join the national arsenal. These missiles, capable of being launched from land or sea, will transport their payloads approximately 1500 miles. Reportedly, the Russians are working on similar weapons.

Thus the modern Army can provide its field commanders with a range of weaponry in rockets and missiles that permits him to apply the scalpel, not the executioner's axe, to borrow a phrase from Dr. Edward Teller, the noted hydrogen bomb scientist. Following our own traditional Army policy, measured force can be used selectively —the right amount, the right time, and right place. The Russians have not ignored rocket and guided missile development in the modernization of their military forces. It can be assumed the Russian Army has put great emphasis on rocket weapons.

Progress in the related fields of rockets and guided missiles will by no means eliminate the ground forces. The Infantryman and his fellow soldier traveling in tanks and armored carriers will be needed to occupy, hold, and possibly fortify terrain. Even in missile warfare, we cannot rule out the possibility of localized skirmishes and engagements with guerrillas or small, roving enemy forces. The ground commander will require troops and planes to locate and identify targets, to determine enemy intentions, and to essay his capabilities.

Korea and European experience of World War II taught us that there will continue to be a need for fighting men to reestablished demoralized civilian populations, to apply friendly controls, to maintain communications, to throw up bridges, to build airstrips and road nets over which to move men, materiel and supplies.

Land warfare revolves around the possession of key terrain points such as road junctions, rail marshalling yards, border strongpoints, and control and command centers. The Army must have the capability to seize and hold these points. It must have, ever-present, the capability of exerting its will upon hostile forces. The new Army makes use of airborne troops and equipment for the rapid exploitation of havoc wrought by long-range firepower.

In the immediate future units of the mobile Army can be transported by organic aircraft. Perhaps in the not-too-distant future, the guided missile may serve another purpose by replacing the freight-carrying plane. For it is my firm conviction that we have entered a new era in transportation. In the giant missile we have a means of utilizing the most efficient and effective delivery system man has yet developed. Within the Army our forward looking planners are considering the guided missile as a potential of great promise with which to deliver all the resources they require for control of the land.

With rocket power as their propulsive system, future guided missiles will rise far above any intervening obstacle, follow a trajectory directly to the target, and put down the forces required to seize and hold such an area within a time span so brief as to defy attempts to prevent their arrival.

This is the era upon which your Army is now entering and which it will aggressively exploit as rapidly as its resources permit to strengthen the national defense.*

[*The views expressed in this article are those of the author and do not necessarily represent Dept. of the Army policy.*]

Shame on the West—practically all "the modern work in rocket technology" outside the Soviet Union represents "purely military effort" and no other. So charges Professor A. A. Kosmodemiansky in his biography of Constantin Tsiolkovsky, the famed Russian pioneer of rockets. This book, issued in 1954 in the same Soldier and Sailor Library series by the Soviet War Ministry, tells Russian troops that "reactive missiles can be hurled any distance," that guided missiles indeed make conventional guns wholly obsolete. Firing from such artillery "over distances of more than 100 kilometers will soon be economically unprofitable." For the walls of such guns have to be "extraordinarily thick and these guns quickly wear out due to the great pressures and temperatures" caused by the tremendous quantities of conventional explosives used in these guns. "How much simpler and more advantageous the modern use of rocket missiles, this very latest artillery!"



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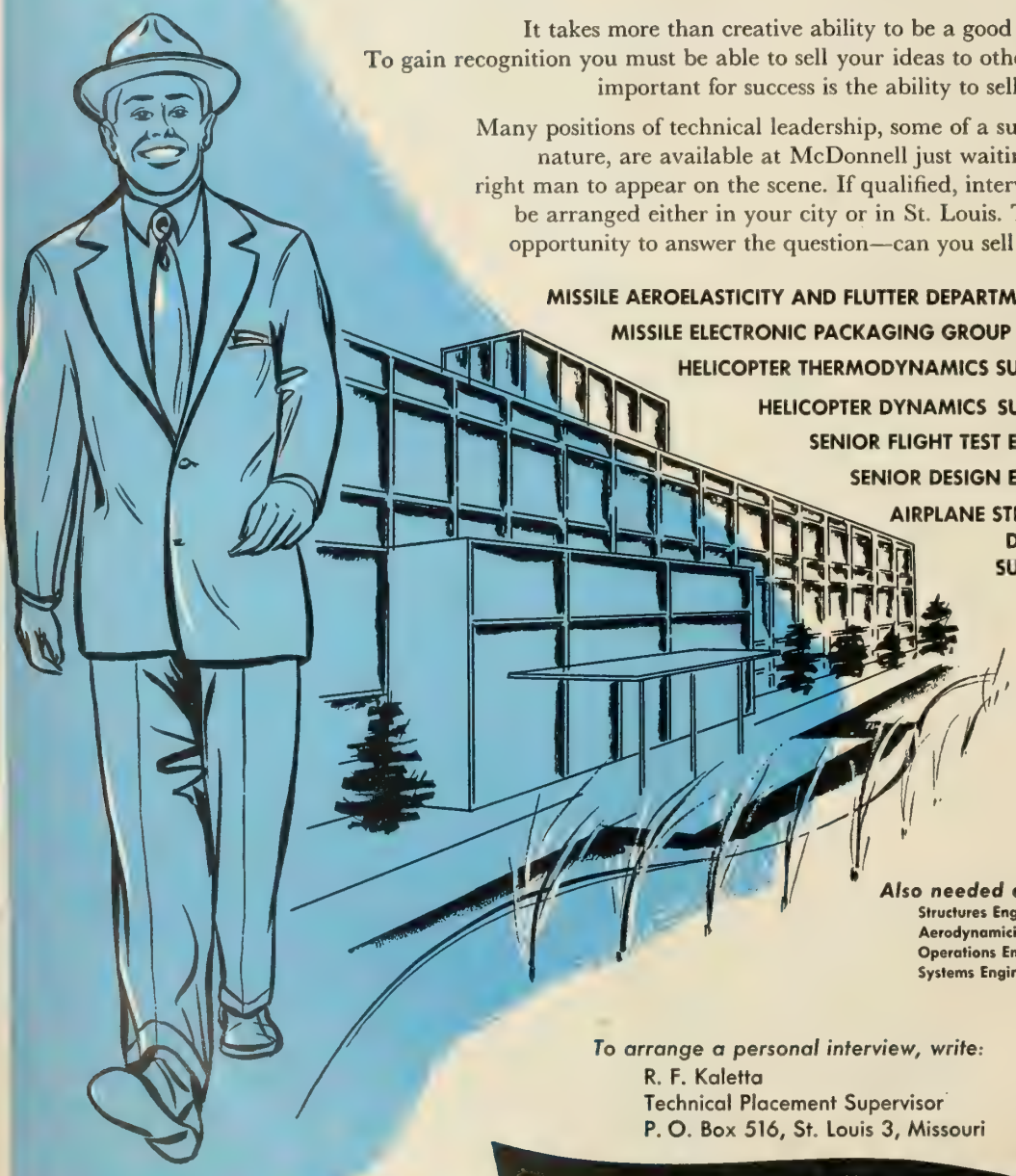
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Washington Spotlight

By Henry T. Simmons

A look at the Air Force's new budget readily illustrates the financial bind confronting the airmen. Despite insistence of top USAF witnesses last spring that fiscal 1958 appropriations would have to be substantially increased over those voted for the current year to maintain the current development programs, the new budget embodies reductions rather than increases in two key accounts. For R&D, the Administration asked Congress for $661 million in new money, compared with $712 million voted for the present year. And $1,712 million was requested for procurement of missiles and test vehicles in fiscal 1958, against $1,948 million voted for this year.

•

If the new money wont be sufficient for all USAF development programs, at least it will assure continued high-pressure work on the *Atlas, Titan* and *Thor* ballistic missiles. Further evidence of the amount of beef behind this program was supplied last month by Maj. Gen. Bernard Schriever when he disclosed that the Western Development Division, in addition to perfecting the hardware, will also assume the initial operational capability for the weapon systems within the USAF. This unprecedented step is deemed necessary for the proper development of the weapon's operational environment and will give WDD control over training facilities and techniques, operational installations, logistic support and other details normally left to the using command.

•

The Northrop *Snark* intercontinental missile appears to have weathered the budget storm in good shape. The weapon is scheduled to go to the Strategic Air Command of the USAF for training and operational purposes, perhaps before the end of fiscal 1958. Though the turbojet-powered *Snark* lacks the speed and altitude of the more glamorous *Navaho,* it has one incomparable advantage: it is here and the *Navaho* is not.

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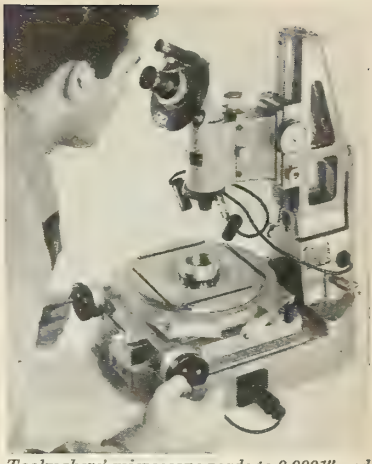
The Air Force will support development of the *Jupiter* IRBM project for at least another year as a hedge against the utter collapse of the *Thor* program, according to Pentagon insiders. Still a mystery is where the money will come from. Most likely source: Defense Secretary Wilson's emergency kitty for R&D projects. It contained $68 million at last count, and all three services are in hopes of getting a slice of it.

•

"It looked like an atom bomb going off," commented one official after viewing a film of last month's spectacular *Thor* misfire at Patrick AFB, Fla. The big missile hardly cleared the ground before it exploded and drenched the area in a lake of fire. One report blamed the engine for the failure; another said the trouble was up-system from the engine and looked like a valve malfunction. First firing of the vehicle had been delayed for weeks because of leaks and hung valves encountered in static tests.

•

Most parties agreed that the *Thor* mishap stemmed from a minor flaw and that the program would not be set back. Nevertheless, there was a disturbing note to the situation. The *Thor* embodies most of the components designed for the *Atlas* and *Titan;* its powerplant is one of the Atlas boosters. Thus any difficulty with the mid-range *Thor* is bound to have ominous implications for the more ambitious weapons which follow it.



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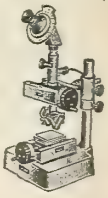
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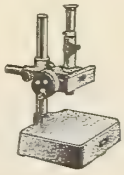
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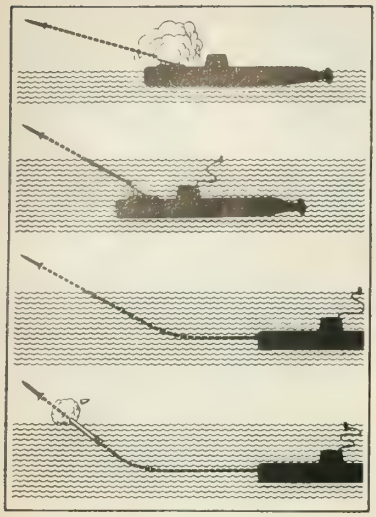


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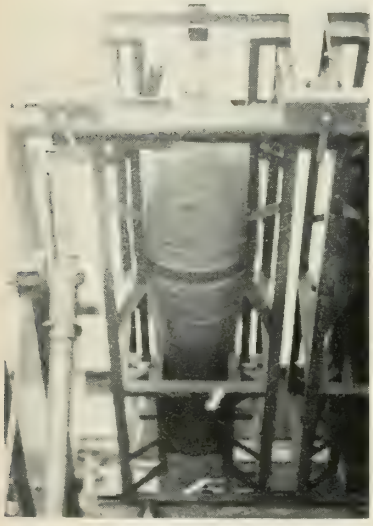
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Submarine Missiles: Reds Move Ahead



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Top U.S. Navy officials have told the House Armed Services Committee that the Russians now have a total of 600 submarines, over a third of the way to their goal of 1,200. This compares to a total at latest official count of 400 for the U.S.

Add to this the *Comet*, Russia's Fleet Ballistic Missile, and the total works out to a considerable threat to the U.S. and it's over 5,000 miles of coastline. Admiral Burke has pointed out that any significant deployment of Russian submarines could well be the tip-off for an attack.

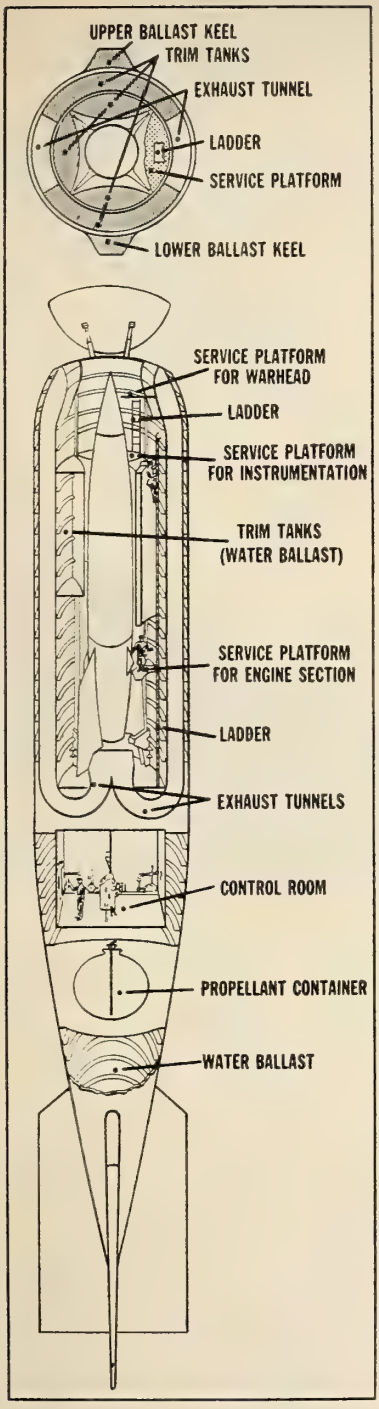
Russian submarines, currently being built at a rate of two-to-three a month, are direct descendents of the World War II German long-range W-class vessels with snorkels for submerged operation and combination diesel-electric powerplants. There are no reports that the Reds have either nuclear-powered submersibles or have gone to the high-speed underwater *Albacore* type of hull. Even with improvements since 1945 it's doubtful if Russian submarines now being built are capable of more than 20 knots on the surface or eleven knots at snorkel depth.

Though there's little reliable information as to the state of Russia's submarine missile art, the basis they started from 12 years ago—two methods for underwater launching worked out by the Germans but never put into actual operation. In the one case small solid-propellant 21 cm *Borsig* rockets were mounted in external racks on the submarine's deck. These could be fired from under water by controls mounted within the submarine. This weapon system now has





Collapsible launching gear for solid rockets being installed on W-class long-range sub. Rack holds six missiles.



Peenemünde left three of these submersible missile launchers to the Russians. Container is 100 feet long, holds V-2-type rocket with propellant supply, control room and water-ballast tanks. Russians also have subs capable of direct launching of fleet ballistic missiles. Russians could tow these containers to undetected sites in the Atlantic or Pacific oceans. Disadvantage of this weapons system lies in the fact towing speed is slow (15-20 knots); sub could easily be detected and attacked by missiles such as our Rascal.

been developed to perfection by the Soviets.

The other method involved the surface firing by a submerged submarine of what basically was a V-2 rocket with a one ton warhead and a range of several hundred miles. There seems little doubt that the Soviet Union must have made considerable improvement in these devices and is now approaching a concept similar to that the Navy envisages for the *Polaris*, namely a 1,000-to-1,500 ballistic missile carried internally in submarines and launched from a fully submerged position. As to whether these are in operation now or not, U.S. Navy Assistant Secretary for Air Garrison Norton says they are not.

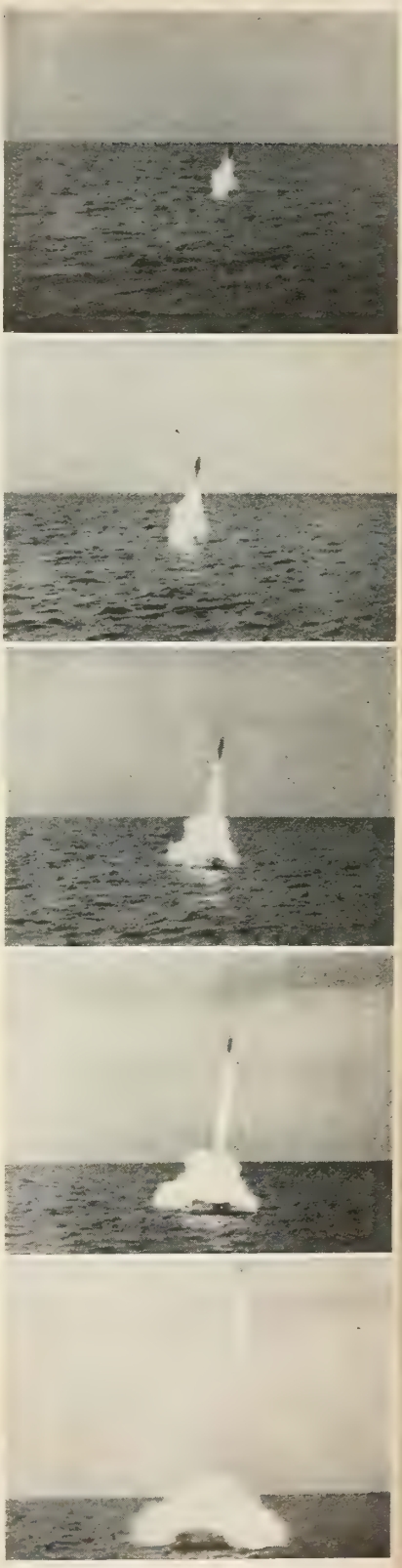
U.S. defense against this kind of attack aims first at destroying the submarines before they can launch their missiles. To this end, the Navy has the *Rascal* and, in advanced state of development, the *Lulu*. Development of nuclear warheads in anti-submarine warfare has been a major U.S. project for some time. Later anti-ICBM weapons like the *Nike Hercules* may be able to intercept and destroy these missiles before they reach detonation altitudes.

Meanwhile, the Red submarine fleet and its probable missile potential form the greatest single threat to United States military security. Even though U.S. anti-submarine warfare has reached a high state of effectiveness, it's still far from 100%. And with small-but-powerful nuclear warheads a reality, even 20% of Russia's submarine fleet launching even primitive missiles against our coastal cities could cause severe damage.

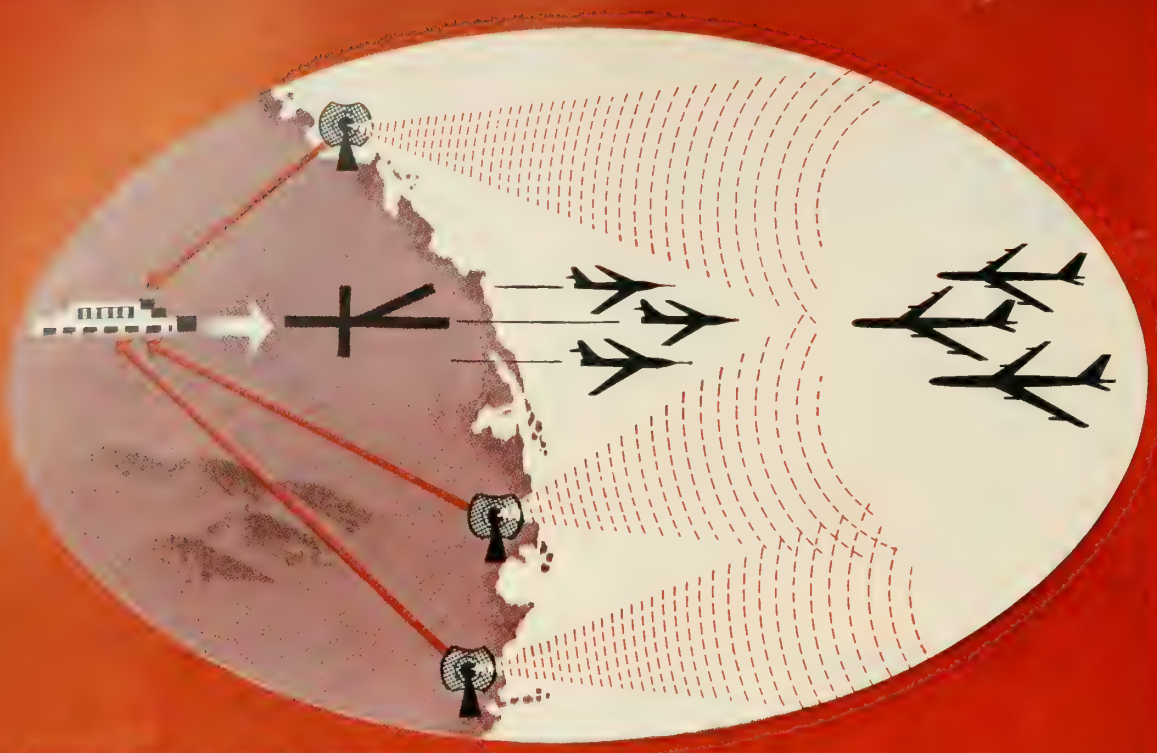
It is interesting to note that the Russians have put great emphasis and faith in any weapon system developed by the Germans. In terms of missile systems, all major German concepts seem to have been adopted and accepted fully by the communists, such as the V-2, the *Reintochter*, the *Borsig* solid-propellant sub missiles, as well as the container-hauled V-2s.

Obviously, the Russians had great faith in the Germans and their missile technology and capability; several German scientists have enjoyed high privileges in the Soviet since the last World War. But indications are the Russians are getting tired of playing with German post-war hardware; they have activated several all-Russian missile programs. There is no reason to doubt that an all-out submarine-missile program is heading the list.

★



Solid rocket zooms out of the Baltic Sea and into the blue skies over Peenemünde.



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Proposal from behind the iron curtain:

SATELLITES

for checking Einstein's relativity theory

By M. Subotowicz
Physics Department,
University of M. Curie-Sklodowska
Lublin, Poland

As the science of earth satellites develops it may well be possible to experimentally check Dr. Albert Einstein's General Theory of Relativity. In recent years this revolutionary physical concept has come under closer and closer scrutiny by mathematicians and physicists the world over. As more and more empirical evidence of the innermost structure of matter is brought to light, more and more does Einstein's theory seem to fit. Or does it? That is the question.

In using it to explain newly suspected phenomena, the theory continues to provide a great many logical answers. But, there is an increasing suspicion that it may not be the full answer in itself; that parts of it may be wrong or that it simply may be incomplete. Recently, for example, experimental results of work with matter at temperatures close to zero degrees Kelvin raise doubts as to Einsteinian time hypotheses.

If the doubts about some phases of Relativity could be proved or disproved conclusively in controlled man-made experiments it would greatly facilitate the analysis and evaluation of work in the study of matter and the solution of science's basic mysteries, such as the true nature of gravity.

While the early satellites to be launched by the U.S. and the Soviet Union during the International Geophysical Year may not be sufficiently perfected to help in the resolution of these problems, later models may well be capable of providing us with specific answers. These would be satellites able to remain stable in their orbits for periods of a year or more. Some would have to circle the earth at an altitude, say, of 2,000 kilometers with a period of under two hours. They would not necessarily have to be either manned or recoverable. But the means of very precise continuous measurements would have to be provided. And they would be rather larger than presently planned early vehicles.

The General Theory of Relativity is the theory of gravity, time and space as formulated by Einstein. It is the theory of the relationship of the properties of space and time with matter and its motion. The experimental verification of the results of the Special Theory of Relativity is generally not so difficult and has been performed with great accuracy. But experimental verification of the General Theory of Relativity is very difficult.

Einstein suggested three effects to prove the General Theory experimentally. According to Einstein these three effects could be measured:

1—the gravitational shift of the spectral lines.

2—the gravitational deflection of light.

3—the advance of the perihelion of the planet Mercury.

M. Subotowicz is "a scientific worker" at the Physics Department of the University of Madame Curie-Sklodowska in Lublin, Poland. This article, which he has titled "The Artificial Satellite of the Earth and the Possibility of the New Experimental Verification of the General Theory of Relativity," was written exclusively for MISSILES & ROCKETS.

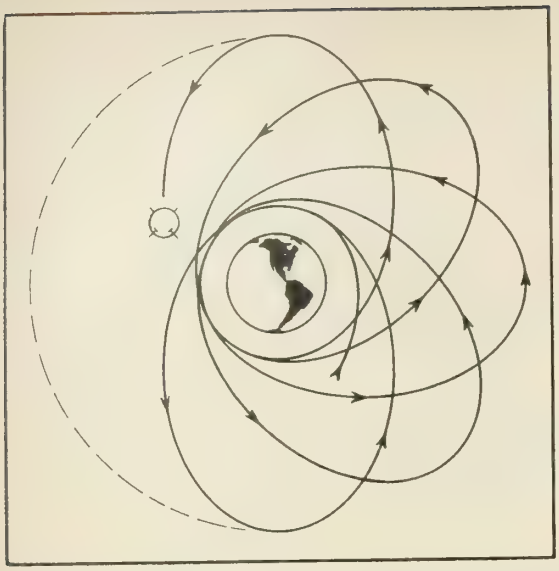
I won't discuss these three effects in detail here. They can be found in special books on the General Theory of Relativity—Tolman, 1949; Moller, 1952; Fock, 1955. I shall give the results of the measurements of the effects proposed by Einstein. Indeed the gravitational shift towards the red of the sun spectral lines and other stars has been observed. The same effect for the massive (companion of) Sirius is about thirty times as large as for the sun.

The gravitational deflection of light was observed in the gravitational field of the sun. The angle of deflection for a ray of light, which grazes the limb of the sun, is 1.75 seconds of arc. This effect has been tested by observations during total eclipses of the sun on the apparent positions of stars. The light of those stars has passed close to the limb of the sun.

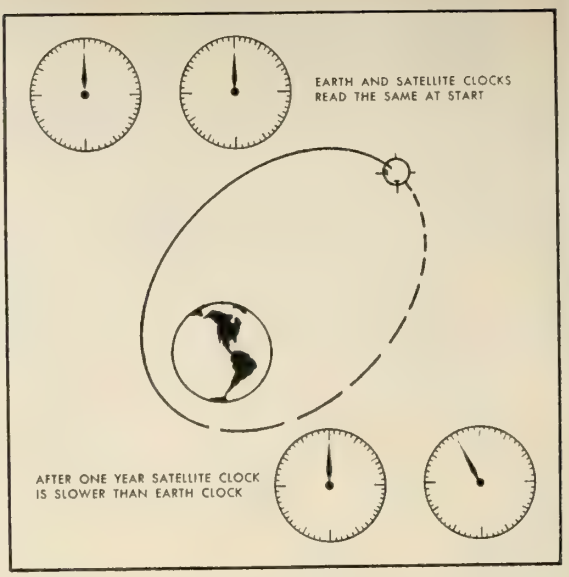
The agreement between predicted deflection and the observations would be accurate, except that the shift is just inside the limits of experimental error. This effect can be treated as having been tested only qualitatively.

As the third effect to verify the General Theory of Relativity Einstein has predicted the advance of the perihelion of Mercury around the sun. This he predicted would be at the rate of 42.9 seconds of arc per century. After subtraction of the effect due to the perturbation by the other planets, the observed advance of the perihelion is 43.5 seconds of arc per century. This is in excellent agreement with the predicted theoretical value. The advance of the Mercury perihelion was known before Einstein's theory. That theory explained this effect.

The existence of only these three effects to prove experimentally the General Theory of Relativity shows



The perigree of a satellite orbiting about the earth for a year would, if Relativity calculations are valid, advance more than the perihelion of the planet Mercury does around the sun in 100 years, and might thus provide another check of Einstein's theories.



According to time lengthening theories in Einstein's General Theory of Relativity, a clock in an earth satellite would run more slowly than one at relative rest on earth. Subotowitz says the difference in a year could be measured with available equipment.

that Newton's theory represents a good approximation for all gravitational phenomena inside the solar system.

Two Out of Three Verifications

In the use of an artificial satellite for verification of the General Theory, only two of these three effects are of importance. They are:

1—the gravitational shift of the frequency of electromagnetic wave radiation (from the satellite) in the gravitational field of the earth.

2—the advance of the perigeum of the satellite orbit in its motion around the earth.

But there are yet two more relativistic effects to prove the General Theory. It is impossible to verify these by observing known celestial bodies. They are:

3—the relativistic "effect of rotation" of the spinning central mass (earth) on the advance of the perigeum (perihelion) of the satellite (planet). The influence of the Lense and Thirring (1918) predicted "effect of rotation" on the advance of the Mercury perihelion is very small—only —0.01 seconds of arc per century.

4—the lengthening of time on the artificial satellite moving in the gravitational field. This effect is connected with the General, not the Special Theory of Relativity.

I shall give here some results of the calculations of all these effects in connection with the problem of artificial satellites (Ginzburg, 1956; La Paz, 1954; Winterberg, 1956).

Suppose that the height of the satellite orbit above the earth is $h = 800\ km$. Then the relative change of the frequency of radiation emitted by the satellite and observed on earth would be

$$(\Delta^{\nu}/_{\nu})_{gravit.} = 7.6\text{x}10^{-11}.$$

Since the source of the radiation, the satellite, has a smaller gravitational potential than the receiving station (the earth's surface), the observed shift of the electro-magnetic radiation should be the violet shift. It would not be a red shift, as in the case of the sun or another star.

But the relative shift of frequency connected with the Doppler effect is of the order

$$(\Delta^{\nu}/_{\nu})_{Doppl.} = -3\text{x}10^{-10}$$

for this same satellite. Thus, the Doppler effect shift is about four times larger than the gravitational shift.

It is, unfortunately, impossible to separate these two effects in one experiment. Thus experimental verification of the General Theory in this way is quite difficult. Life would be considerably simplified, however, if the satellite were circling along a much higher orbit, where h is greater than the radius of the earth.

Advance of Satellite Perigeum

For the above-mentioned satellite, the advance of the perigeum as a consequence of the influence of the gravitational field of the earth is quite large, about 1500 seconds of arc per century. This is about forty times greater than for the Mercury perihelion. According to La Paz (1954), a one-year observation of a satellite would be more efficient than a 100-year observation of Mercury.

According to the theories of Lense-Thirring (1918), there is an effect of the spinning central mass on the perigeum motion of the circling body. For the Sun-Mercury system, this effect is very small, hardly —0.01 seconds per century. For an artificial satellite circling at a height $h = 400\ km$ above the earth with a period $T = 1.54\ hr.$, the advance of the perigeum as a result of the earth's rotation would be about —43 seconds of arc per century. Thus the gravitational effect of the rotation of the earth would be as great for the satellite as relativistic effect on perihelion advance appears to be for Mercury.

The effect here discussed is connected with the General, not the Special Theory of Relativity. It concerns the Doppler effect in the presence of gravitational fields. And with the Doppler effect is connected the analysis of the time on earth and on the satellite.

The General Theory of Relativity treats with both longitudinal and transverse Doppler effects. The transverse Doppler effect is indirectly connected with time-lengthening and is not dependent on the direction of the motion

of the radiating body (the satellite) relative to the observer. As time passes the difference in the readings of two watches, one on earth and the other in the satellite, will grow in accordance with the above-mentioned transverse Doppler effect. In the General Theory of Relativity there are formulas dealing with the ratio of the time intervals of two synchronized watches in the reference systems of emitter and observer.

Neglecting the small influence on the earth's rotation on time lengthening, the following simple expression for the ratio $\Delta t/t$, where Δt is the difference of times measured on earth and in the satellite and t is the time measured on earth.

$\Delta t/t = A/r_2 - 3a/2r_1$; $a = G.M./c^2$

Where r_1 is the radius of the satellite orbit measured from the center of the earth; r_2 is the radius of the earth; G, the gravitational constant; M the mass of the earth; and c, the velocity of light.

According to Winterberg (1956), for a satellite at height $h = 1650$ *km* above the surface of the earth is $\Delta t/t = -1.3 \times 10^{-10}$. This means that in one year, a watch in the artificial satellite should be 4.2×10^{-3} seconds late relative to the watch on earth. A watch with an accuracy of 10^{-11} could be used to verify this effect. The "atomic watch," with an accuracy of 10^{-12} would meet these requirements.

Thus the coming of the artificial satellite offers the possibility of yet additional scientific work of the greatest importance. It should be noted, however, precise measurement of the effects of interest (rotation effect and time lengthening) will require a precise knowledge of all deflections from the stable satellite orbit. Some of these deflections include: the perturbations of the sun, moon and the other planets; the inhomogenity of the earth's mass distribution, the resistance (of the rests) of the atmosphere, tide effects.

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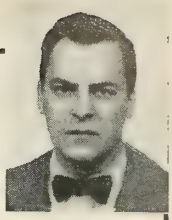
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Aerophysics

By Seabrook Hull

The U.S. is well on the way to overcoming Russia's reported lead in high-energy particle accelerators used in the basic study of matter. Prof. Luis W. Alverez (Cal. Tech.) used such equipment in the mu-meson "cold fusion" of light and heavy hydrogen into helium, the first real break in man's efforts to develop a controllable thermo-nuclear rocket motor.

Dr. Tihiro Ohkawa and Dr. Lawrence Jones of Midwestern Universities Research Association reported before the American Physical Society on a "siamese twin" accelerator design to give a useful energy release of 30 billion electron volts. Proposed are a pair of backed-up 15 billion e.v. accelerators whose proton beams intersect. To achieve this power by conventional stationary target machines would require a theoretical capacity of 540 billion e.v. Largest accelerator in the U.S. is the Bevatron at the University of California at Berkeley with a useful power of two billion e.v. A six billion e.v. machine is now under construction at Brookhaven National Laboratory, reportedly to be on a par about with Russia's best.

•

The Forty-second Annual Report of the National Advisory Committee for Aeronautics gives a new lease on life to transpiration cooling as a possible answer to aerodynamic heating; seems this kind of cooling tends to move the boundary layer separation point downstream. The NACA report also notes detailed investigation of several of the so-called exotic fuels including octene-1, aluminum, aluminum-octene-1 slurries, magnesium, magnesium-octene-1 slurries, diborane, pentaborane, boron, boron-octene-1 slurries, hydrogen, alpha-methylnapthalene, and graphite. In the field of high temperature lubricants, NACA Technical Note 3657 gives data on graphite and mixtures of graphite with lead oxide, cadmium oxide, sodium sulfate, or cadmium sulfate as solid lubricants. Among the temperature tolerant structural materials covered by NACA during the last year are melamine-resin glass-fabric laminates and silicone-resin glass-fabrics—up to temperatures of 600°F. And what may perhaps be a significant note in the incremental stey-by-step approach to manned space flight, this comment: "Because of the loss of the X-2, the need for earliest possible completion of (the X-15) has become imperative." Manned flight testing of superthermantic flight is now limited to a little over Mach 2.0 in the X-1B and X-1E.

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As man's operational devices depend increasingly on a working knowledge of the basic structure of matter and energy and on clear comprehension of advanced theories such as Einstein's General Theory of Relativity, "major technological break-throughs" are more impressive; their attainment, more difficult. It might help if more people understood the basic theories that have superceded the classical concepts of Newton, Gallileo, Euclid, etc. For the non-physicist, "The Evolution of Physics" by Albert Einstein and Leopold Infeld (1938, Simon & Schuster), covers field, realtively and quanta; is simple, thought-provoking.

•

A Russian scientist claims he has studied chemical reactions at pressures up to 500,000 atmospheres in the laboratory; at 100,000 on the pilot plant level—both records, if true. At these pressure levels, classical chemical and physical laws do not necessarily apply, due to resistance of atoms to compression.



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Soviet Missile Science Profile

. . . from Dr. S. Fred Singer, *Physics Professor, Maryland University*
Dr. Leon Trilling, *Fluid Dynamics Research Dept., M.I.T.*
Dr. Hurd Willett, *Professor of Meteorology, M.I.T.*
Michael Michaelis, *Phycisist, Arthur D. Little, Inc.*
Dr. Albert Parry, *Chairman, Russian Studies, Colgate.*
Alex G. Korol, *International Studies Institute, M.I.T.*
Andrew G. Haley, *Director, International Astronautics Fed.*

Catching its interviewees in between on-time airliners, skiing dates, mid-year exams, baby-sitting chores and book deadlines, m/r's editors traveled hundreds of miles with recorder and camera to bring you this intimate profile of the men and methods of Soviet Missile Science. The better we know them, the better our chances of staying ahead in the current race for missile supremacy.

Soviet Satellite Plans Sophisticated; Astrophysics Research Well Advanced

Q. *Dr. Singer, can you tell us something of Russia's plans for launching an artificial earth satellite?*

A. Dr. Leonid Sedov first announced in 1955 at Copenhagen that Russia would launch a satellite during the International Geophysical Year. This was repeated by Bardin at Barcelona. Last year in Rome, Sedov gave some details; said that their satellite would measure pressure, temperature, density and magnetic field. I questioned him rather closely as to whether they were really going to measure temperature, to which he replied, no. To measure temperature under satellite conditions is very difficult.

Q. *Did he indicate the size of their satellite?*

A. No. But when I asked him whether they were going to measure magnetic fields, he said yes. This gets into size because you have to provide storage equipment and you have to play it back in order to transmit it when the satellite is over the receiving station. Play-back must be at a very rapid rate, and therefore with high transmitter power which means several watts. This rules out transistors. It also requires the use of B + batteries. This really adds weight.

Q. *Have you done a rough calculation of what the minimum weight would be?*

A. Yes. I would estimate it's at least 50 pounds, if they want to measure magnetic fields in the proper way. Properly packaged, it could still be fairly small, however. My guess is that the Russians will have a satellite with a near-polar orbit or an orbit which is much more inclined than ours, and with internal recording and playback. It's a more sophisticated satellite than our first ones.

Q. *Did Dr. Sedov make any claims as to how long it would stay in orbit?*

A. No, he didn't, but of course with sufficient propulsion in the rocket assembly, you can make the satellite stay in its orbit indefinitely. In an orbit at about 400-to-500 miles instead of 300 miles, the chances of long life are enhanced quite a bit. And from some indications, particularly in your magazine, it seems like they have the rocket equipment to do such a job. But of course this doesn't mean they can do it immediately. It still takes some work. It takes some thinking, as Bardin said.

Q. *Do you think they're bluffing on the satellite?*

A. In a Western Gear advertisement in the Wall Street Journal, Mr. Bannon, the President of that firm, raised the question of whether they've got a satellite ready for launching or whether they're just bluffing. As you know, they copied the Mouse. The question is: Are they bluffing and just covering up by printing this picture from Popular Science, or was the artist just lazy and looked around for something that looked like a satellite to put in the article. I think it's probably the latter. I don't think we should underestimate the Russian effort.

Q. *Wasn't the Mouse your idea?*

A. Yes. It is a more sophisticated satellite than the Vanguard and I think it would have come first except that the Vanguard propulsion system is fairly limited.

Q. *Can you give any indication of the level of Russian science in the fields with which you're familiar?*

A. In astrophysics and in cosmic rays the Russians have done outstanding work on the theoretical side and fair work on the experimental side. They've made some very important discoveries, particularly in the field of radio astronomy and have done a great deal of theoretical work of some importance on the origin of cosmic rays. You can say they have contributed to the world's supply of knowledge. The reason for such a great amount of activity in theoretical astrophysics is twofold: First, you can learn a lot about the universe, which has great scientific interest. Second, the energy sources in the universe are based on fusion power, and the more we learn about how the universe operates, the better we can understand fundemental physical laws.



Q. *Would their knowledge of astrophysics contribute to their work in nuclear physics?*

A. Not necessarily, but they do have excellent theoretical nuclear physicists. There is great incentive for Rus-

sian young men to go into the natural sciences. I think the incentive is partially financial but most of all a matter of prestige. And, the support they get for their work is just tremendous. Russian cosmic ray physicists may have fifty assistants working on data, reducing results, laying out experiments and so on. This is a tremendous number compared to our average large cosmic ray group of that type which might have, maybe, five assistants. They just don't care how much money they spend and as a result often spend it very uneconomically and wastefully. And, as well as the men, they have some good equipment. Our nuclear physicists who have been over there are very impressed by their large accelerators. They are well engineered. So apparently they're developing a good crossbreed team of pure scientists and engineers, which is of great importance. Their system of technical education is quite excellent and heavily endowed. Some Russion scientists I've talked to have graduate classes with maybe a couple of hundred students where we have only a few.

Q. *In your field of physics do they tend to quote American and other foreign figures rather than their own?*

A. They always cite their own calculations and prolifically. I think this is part of the way they operate. But when it comes to experimental results, they pretty much have to fall back on Western figures. They don't have the experimental data, but they're good interpreters.

Q. *Does this mean that they tend to take their lead from non-communist sources, and then, once they know the basic problem, to tackle it on an all-out basis?*

A. This is not always true. Sometimes they take on experiments themselves which are quite difficult and expensive and not very inspiring. This is because they are not in close touch with the Western world and don't keep up. In some fields they are completely out of fashion. In others they are right at the forefront.

Soviet Scientists Competent, Sociable; Missile Hypersonic Knowhow Up to Date

Q. *Professor Trilling, what is your experience with Russian science and scientists?*

A. I have looked at their education system in aeronautical engineering. Also, as a practicing aerodynamicist I follow their technical papers. I have talked with acousticians who attended the Second International Acoustics Congress here at MIT last June, and to aerodynamicists at the International Congress of Applied Mechanics in Brussels.

Q. *Were they easy to talk to?*

A. Oh, yes. They were trying to contact all the people they had heard of in the U.S., trying to find out what they were up to and quite willing to say a good deal about what they themselves were doing. Whether or not they were telling everything is hard to say. They were quite willing to talk, though this depends a bit on the individual. One senior gentleman who came up the hard way was very skillful at evading questions whereas another one a little bit younger and with a different personality was only too anxious to talk—was going out of his way to find people to talk to on the technical problems he was interested in, what his ideas were and how he was going about it. In fact at times, the older one had his hands full trying to keep the younger one from talking too much.



Q. *Did you get the idea that their level of accomplishment was on a par with ours?*

A. On the average, the answer would be yes. In some areas they're doing possibly better than we; in others we are doing a good deal better.

Q. *Did they describe their research equipment?*

A. No. In fact they were fairly careful not to talk very much of their research equipment. Professor Leonid Sedov said the volume of experimental work in the USSR was a good deal lower than in this country, so that they were attempting to use their facilities as effectively as possible. I have a feeling that they are not too active in fundamental experimental research, but they are extremely strong in analytical research.

Q. *With regard to education, what is the significance of reports that they're graduating increasing numbers of engineers? Do they simply order a promising student to go into, say, aerodynamics?*

A. Well, no. It isn't as crude as all that. The carrot gets you much farther than the stick. There are all sorts of incentives. In the first place there is no equivalent in the Soviet Union to our class of administrators and executives. The technically trained people do that work. They are the socially leading groups. So there is an inducement for them to go into natural and applied sciences. And, a student in aeronautical engineering, for instance, will get a bigger fellowship than a student in history or ancient languages. The number of applicants for the better technical schools is a good deal higher compared to vacancies than the number of applicants for schools which train librarians and such. Students are not told what department they should register for individually. Still, the total number of students in various fields is regulated. It is decided by the Government that 65% of college vacancies will be in the natural sciences. In this country, I think this is correct, about one in eight children eventually go to college. In the USSR it is likely to be one in twelve. A greater proportion of these are in the technical fields.

Q. *In talking with Russian scientists, did you ever get the impression they were trying to pump you?*

A. It depends on the individual. Without quoting names, I would say that some gave me the impression of trying to get the most information at the least cost in contributions by themselves. Others, on the contrary, spoke freely and were apparently quite willing to talk about their own work.

Q. *Can you be specific as to the state of the missile art in Russia?*

A. In theoretical work they are extremely good. It's in experimental work where they are not so good. In the theoretical work I think they are at least as good as we, apparently having spotted some problems a few years ahead of us. Exactly where they are now is difficult to tell because of security and that sort of thing, but they seem to know what they are talking about, and they grasp the fundamental problems involved in hypersonic flow past a missile-like configuration. They know how to go about making reasonable calculations. So far as the boundary layer is concerned in hypersonic flow—the bow shock wave and pressure distribution—they gave a paper about a year-and-a-half ago at a meeting in West Germany that thoroughly indicates they know how to calculate pressure distribution of a sharp-nosed body as well as a blunt body in hypersonic flow. And the comments they make indicate they are not only interested but reasonably well advanced.

As to heat transfer, all I got from them was that there is a group doing experimental work on heat transfer and presumably doing all right. At any rate they know what the heat transfer problem is. Not very long ago, a paper

was published by L. E. Kalikhman, who has been doing high speed boundary layer research in the USSR. He wrote on the reduction of heat transfer through a boundary layer by injection of a cold, light gas through the wall. This is a technique with which we are also playing. It shows that they know what they are about. However, how well they are succeeding is hard to tell because the experiments which Kalikhman quotes to support his calculations are American measurements.

Q. *Why did he quote American measurements?*

A. I think this is standard procedure with people associated with defense establishments. But people in the power stations ministry, for example, who also do gas turbines, publish local data quite freely . . . interferograms of high speed flows past cascades, heat transfer measurements, boundary layer profiles and all sorts of things, because, I suppose, this is a research establishment of a non-sensitive industry. It raises the question of whether people in one industry talk to people in another.

Q. *Could you name some of the outstanding people in Soviet aeronautical engineering?*

A. I think the two leading men in fluid mechanics are Sedov, who is the theoretician, and S. A. Christianovich who did important work in transonic flow in the late 1930's and early '40's and who is now Secretary of the Engineering Section of the Soviet Academy of Sciences. As such, he has much to say about what type of engineering research is done.

Q. *Have you seen any signs that scientific theory is still politically dictated?*

A. Not in any of the aeronautical sciences.

Q. *They are competent competitors, then?*

A. They're quite competent, but they're rather dedicated to the state. They have a measure of national fervor which makes them very intense and hard working. They believe in Soviet science, not science in general—a factor that's just a bit disturbing.

Q. *You mean the advantage it may give them?*

A. Whether this really is an advantage in the long run is a question. It leads to an approach to scientific research which is a little bit too much day-to-day, a matter of concentrating on today's problems today and letting tomorrow's problems get solved tomorrow. A disadvantage is that the right fundamental problem may not be attacked early enough. It does have the advantage of concentration of effort. But it makes them sometimes rather forbidding.

Soviet Theoretical Work Excellent? Engineering Crude; But Results Good

Q. *Mr. Michaelis, you were at the U. N. International Atomic Conference at Geneva in 1955?*

A. Yes, I had submitted a paper and attended as a participant though not a formal delegate.

Q. *Being British, were you in a better position to talk to the Russians than the Americans?*

A. No, I don't think so. Having lived in America for the previous 5 years, I was not regarded as a member of the British contingent anyway. Generally speaking, it was notable—for the first few days anyhow—that quite a few Americans held off from talking with Russians—and vice versa. Europeans seemed to get to them more quickly, one reason possibly being that many of the elder Russians spoke German, having studied in German universities before World War II.

Q. *Well, in talking with them, were they just like any other group of scientists, anxious for information and willing to contribute fully to the discussion?*

A. Curious and interested, but a little hesitant, I think, at least to start with. The first few days were pretty formal. Then things began to loosen up a little. They mixed well, barring the language difficulty. I got the impression they were holding back on information, because on direct questions such as "where do you get your uranium"? you'd get no answer, or you'd be told "Well, it's sent to us."

Q. *Could this have been all they knew?*

A. One would guess they knew a little more. They were obviously working under fairly strict instructions from home on what to say and what not to say.

Q. *Any more strict than ours were, for example?*

A. That is hard for me to tell. I don't precisely know what our delegates' instructions were. One of the interesting aspects of the Conference, in retrospect, was their exhibition of equipment which showed that even though they were scientifically well advanced and knowledgeable, their technical execution was much less elegant than ours. Instruments and equipment they showed had an archaic look. But from experimental results obtained with them and presented at the Conference one must assume they function perfectly well.

Q. *Do you think their technical achievement in the field compares to ours?*

A. You must distinguish clearly, I think, between technical and scientific—applied as against fundamental research. I would think that in fundamental research they matched us quite well. As far as applied engineering goes, their proposed power station, medical radiation equipment, etc., I think they did not match our standards in sophisticated design work. It seemed a little like what in England used to be called the "string and sealing wax" style. As I say, it's only appearance, and it's very hard to judge from looks alone the reliability of a nuclear power station or whether an instrument is better or worse.

Q. *Did you get the impression that, as scientists, they felt a serious lack at having been unable to wander about the see what the rest of the world was up to in nuclear technology except through translated papers?*

A. Yes. Some said that in so many words—in private conversations They seemed to feel this a handicap, but so did delegates from other nations, bearing in mind the tight secrecy prevailing at least up to Geneva.

Q. *Considering the level of know-how required for early nuclear powered aircraft, what do you think of the state of their art?*

A. This, of course, was not discussed in public, nor privately to the best of my knowledge, being a highly classified area. But, knowing their achievements with large aircraft gas turbines and knowing that as far as nuclear electric power plants are concerned they are not very far behind us on the fundamentals. I would think they are capable of achieving nuclear aircraft propulsion. Extrapolating from their past performance, they certainly seem to have the brains and technical capabilities of solving these problems. Western delegates were surprised in Geneva at how far they had got in their fundamental understanding of nuclear technology. And, in the case of the controlled thermonuclear reaction Academician Kurchatov made a speech last April at the Atomic Energy Research Establishment in England that gave more information on the subject than any nation to that time.



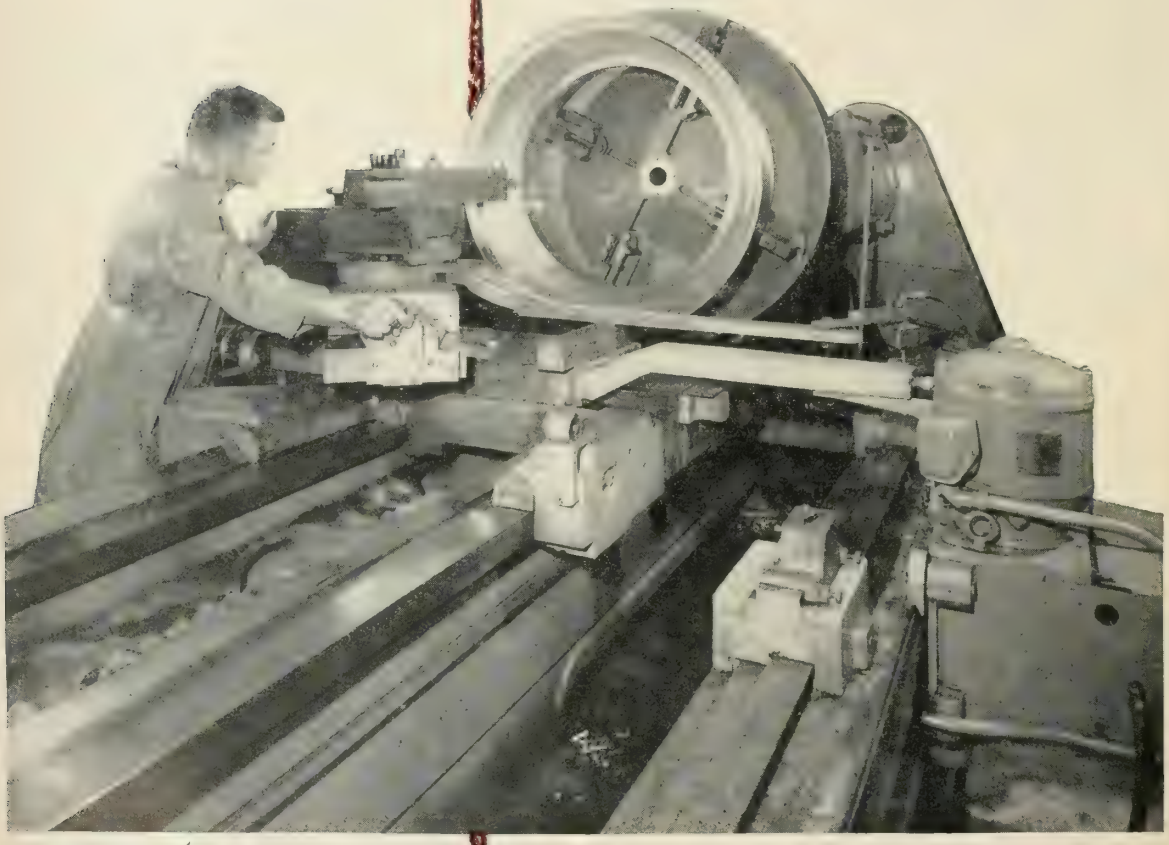
Kurchatov said at the time that the "pinch"

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effect, using electro-magnetic fields, was probably not going to be the ultimate way of achieving controlled mononuclear reactors. He could see limitations. I would think that we've already seen them also. The cold fusion reaction might be a possible alternative approach. At least, Dr. Alvarez of the University of California recently announced the discovery of a low temperature reaction, using a mumeson as a catalyst, to fuse hydrogen and deuterium. It is interesting to note that Dr. Alvarez mentioned that a Russian scientist had predicted the possibility of this reaction some two years ago—another indication that they do not seem to be lagging in ingenuity.

Since particle accelerators are said to be a possibly significant tool in achieving thermo-nuclear reactions, it is interesting to note that, as far as accelerators were concerned, the Russians appeared to be ahead of us in some ways at the time of Geneva. Some visiting U.S. firemen felt that Soviet multi-billion volt accelerators seemed to be further advanced than those in the U.S. So for research in this particular field they may be as well, if not better set than we, for the time being at least. It takes time to build these machines, and they started a bit earlier.

Q. *Did you get the impression that perhaps they lack in experimental ability?*

A. No, I don't think I did. Their experimental work, even though it may sometimes appear crude to our eyes, has certainly produced results which are identical to ours. One of the highlights of the first few days of the conference was the simultaneous release by the U.S., Britain, and Russia of certain so-called n e u t r o n cross-section properties of materials. These had been obtained independently and kept secret until then. The three curves fell on top of one another with remarkable agreement.

Q. *Did you feel that they had gained a considerable degree of scientific intellectual freedom?*

A. Well, more than they've had, I think, until recently. Perhaps they don't have as much as they want. I believe that only a few weeks ago scientists formally asked the Soviet Government for more "scientific" freedom.

Q. *Going back to the reticence of American scientists during Geneva's first few days, do you feel we would gain if more U.S. scientists and engineers traveled abroad to international conferences and the like?*

A. Yes, I do, very definitely.

Red Atmospheric Theory of Little Value; Loss in Translating Technical Papers

Q. *Dr. Willett, what is your experience with Russian science and scientists?*

A. I knew Commander Ryzhkov who was liaison man between U.S. and U.S.S.R. meteorologists during and after the war. I also talked quite a lot with the chief Russian long-range forecaster, Col. Pagava, who was over here at the same time. Otherwise, I know Russian scientists only by personal correspondence, exchange of reprints, etc.

Q. *How deeply do they go into the study of the atmosphere? For example, are they knowelgeable on the degree of dissociation at altitude?*

A. The Russians have done something with ozone, but I don't think that's a specialty of theirs. I would say that Soviet meteorological work has not been primarily of basic importance. They do a tremendous amount in observational and applied meteorology, maintaining large systems of observational stations, and particularly in Arctic meteorology. They have developed some forecasting theory, but their contributions, as far as they're generally known, don't rank with British and Scandinavian meteorology.

Q. *Are their professional papers, when translated, technologically thorough, lucid, etc.?*

A. That's hard to answer, for the language presents certain difficulties in translation. It's a question of whether the translated product means as much to one of us as it did to the Russian.

Q. *Why is this?*

A. They have different ways of saying things. In fact, it goes almost back to a different way of thinking sometimes, and it's pretty difficult always to get an exact equivalent . . . whether from Russian to English or vice-versa, some of the finer points may be lost in translation. I think this is something anybody reading translations of Soviet technical papers should keep in mind. I've studied the Russian language sufficiently that I am aware of differences in grammatical structure and different ways of using verbs that sometimes make the exact rendering of the meaning in the other language awkward. However, despite this handicap, they study very thoroughly all the literature of other countries. In fact, a lot of what you might almost call textbooks are taken from German and American meteorologists.



Q. *Though their efforts at developing meteorological theory haven't been too successful, in other than theoretical work have they made any material contribution to the science, such as in measuring and observational techniques?*

A. Though they developed their own radiosonde about the same time as Finland, I don't think there's a great deal that we have that we wouldn't have had if it hadn't been for the Russians. They've given much information, however, particularly in Arctic meteorology.

Krushchev, Bulganin Chide Scientists; Ballistic Rocket Threat is Not a Bluff

Q. *Dr. Parry, considering all the facets that make up a complete and whole scientist, are there any gaps or lacks in the Soviet scientist?*

A. Well, one is the lack of personal communication with the West. Up to and including Stalin's demise, the Iron Curtain did Russian science more harm than it gave Russian science any security from Western prying and spying. Because Soviet scientists were cut away from Western science so completely, they are not as far ahead as they could have been. There is still some fear on the part of Russian scientists apparently of being in touch with the West, and their leaders, Krushchev and Bulganin, have to remind them from time to time, sometimes in rather crude and rude words, that they have the Kremlin's blessing for making contact with the West. Last February during the 20th Congress of the Communist Party, K & B both chided Russian scientists for being so slow in getting in touch with the West. Apparently K & B feel that if intercourse is allowed, we in the West will learn less of value from the Soviets than they will learn from us. Security is desirable, they said, but not so as to isolate Russian science.

K & B also said that Soviet scientists hide too much from one another. Krushchev put it this way: ". . . too much pointless, parallel work because one group of scientists do not know what another group of scientists is doing." Another point of chiding was that there is too little of the very necessary connection between industrial and university research. "Look at the United States," said K & B, "where universities do so much research for in-

dustry, where industry helps universities, gives them grants, establishes laboratories. Such collaboration is very necessary for the advancement of science and should be emulated in the Soviet Union." Another point of criticism K & B advanced to their own scientists and engineers is that there is too much nepotism, too much favoritism to their own families and to friends of friends of friends.

Q. *Haven't they got a slang word for that?*

A. Blat. Blat covers a multitude of sins. Sometimes it's also called left-handed business, meaning that your right hand pretends not to know what your left hand is doing. It also means illegal; and profit for the individual rather than the state. Another point of Soviet criticism of their scientists, one which has been repeated again and again in the Moscow press, is that Russian scientists like comfort too much, that they have established their institutes in Moscow and Leningrad and do not go into the field. The reindeer breeding institute is in Moscow and not in the Arctic; Marine institutes are in Moscow instead of by the sea. More than one third of all institutions and laboratories run by Soviet industry and two thirds of those belonging to the Academy of Soviet Sciences are concentrated in and around Moscow and Leningrad. Why? K & B say because scientists, their assistants and their families like the soft life, bright lights and comforts of big cities. So the order now is to disperse. Of course, this may be a camouflaged desire to disperse the institutions in case of war.

Q. *What is the reason for the lack of communication between scientists in the Soviet Union?*

A. They don't trust one another.

Q. *Don't they have professional societies that meet and hear papers, etc.?*

A. Yes. But ever since the revolution and the seizure of power by the Communist party, these have been founded or taken over by the Government. Only in very recent months have scientists shown some signs of running these societies the way they want, and not the way the ministry of culture wants them to do it.



Q. *Can you comment on the number of scientists and engineers being graduated by the Soviet Union?*

A. Yes. Quite often the number of scientific and technical graduates of all sorts, as published by the Soviet government and alarming us, is misleading. They give diplomas at lower levels of technical competence where we don't. One elementary example: Here in our country, any farm boy can run a tractor. The Russians send them to special schools. This means special diplomas. Quite possibly some such categories are included in the rolls of scientific talent which we see. Also, in our society, though a number of graduating engineers go into selling or other administrative work, the large percentage really work at their trade. In the USSR you will find a much greater percentage employed as administrators. And generally no matter what field you take, you will find the administrative personnel far exceeding similar U.S. operations.

Q. *Have you seen any signs that the Soviet Union is dissatisfied with the number and quality of scientists and engineers it is graduating?*

A. Yes, a Moscow newspaper article on Oct. 4, 1956 quotes V. Stoletov as saying too few are graduated in biophysics, electronics and in the field of computor design and operation. Too many, Stoletov says are graduated in the humanities; also too many degrees are granted for "nothing of theoretical or practical value."

Q. *Have you noted any influence from the German or other European scientists who have been assimilated into the Soviet Union since the end of World War II?*

A. I think the German contribution to Soviet science has been exaggerated in the Western press, particularly here where Americans just won't give the Russians any credit for their originality. Let's put it this way: The Germans have not been the decisive element in Russian successes in recent years. The Russians do have a tradition of science regardless of any borrowing from the West. Look at Dmitri Mendeleyev (Periodic Table); look at Prof. Peter Kapitza, famous physicist and now Nicholas Semyonov, recent Nobel Prize winner in chemistry. Of course, they did profit from Klaus Fuchs, Bruno Pontecorvo and other such traitors. Pontecorvo may have played a more important role than is generally recognized.

Q. *Now, just going to basic Soviet psychology, the nuclear blackmail that's been going on such as the threats to use missiles against Europe and the Middle East—Are they inclined to bluff? Would they threaten the possible use of rockets if they didn't have the rockets to fire?*

A. They would have the rockets. They know the rocket principle; they use rockets in other fields.

Q. *Do you have any idea of how successful they've been in perfecting guidance?*

A. Answering indirectly, I remember in 1945 after we had dropped our Nagasaki and Hiroshima atomic bombs, one American engineer said to me: "We don't have to fear any Russian atomic bomb because they don't have the precision techniques to make a bomb. Tolerances are practically unknown to them." Yet look. They've got it. They got the proximity fuse when we least expected.

Q. *What can you say about their better ability in theoretical work compared to experimental work?*

A. This goes with their interest in paper work and paper calculations. A typical desire of Russian middle and upper class people is not to sully their hands. If you are middle or upper class, why you wear your nice collar, and your hands are clean. The "do-it-yourself" movement just has not come to Russia among these classes. Our tendency to do it yourself is a tremendous source of our technical personnel. There, we overwhelm the Russians. They use basements to shoot people in, not for workshops.

Reports of Red Education Lead False; More U.S. Than U.S.S.R. Postgraduates

Q. *Mr. Korol, I understand that you are preparing for the Center for International Studies at the Massachusetts Institute of Technology a report on Soviet education. What is it and when will it be published?*

A. The Center has recently completed a two-year study of the Soviet educational system. A book tentatively entitled *Soviet Education in Science and Technology* is scheduled for publication in the fall of 1957.

Q. *How many engineering colleges or universities are there in the Soviet Union?*

A. In the Soviet Union a sharp distinction exists between universities and engineering institutes. Universities train scientists; engineering institutes train engineers exclusively. There are thirty-four universities and approximately 200 engineering institutes. Of the latter, about 24, the polytechnic and industrial institutes, offer training in several branches of engineering; the rest are narrowly

specialized for training in a particular field of engineering and, as a rule, for a particular industry. There are, for example, thirteen institutes for training engineers in "Mechanization and Electrification of Agriculture."

Q. *Much of a sensational nature has been printed in the American press on the quantitative dimensions of Soviet education. What are the real facts? Do they train more people than we do?*

A. The Center's study has been less concerned with quantity than with the qualitative aspect of Soviet training.



Both relative to the population and in absolute figures Soviet enrollment in schools of higher education is well below that in the U.S. For instance, in 1955-1956 American college enrollment was nearly three million and in the U.S.S.R. somewhat less than 1,900,000 including 640,000 part-time, extension students. What is important, however, is that in the U.S. most college students take liberal arts whereas in the U.S.S.R., the reverse is true. Thus in some professions, including engineering, the rate of training in the Soviet Union now for several years has been higher than in the United States.

Q. *What about graduate training? I remember reading that the output of graduate students is about twice as large in Russia as in the U.S.*

A. That is not so. In 1955, for example, the number of Ph.D. degrees earned in the U.S. was 8,840, including approximately 4,400 in science. This compares with some 7,700 Soviet graduate degrees most nearly corresponding to the American Ph.D. (*kandidat* of sciences) awarded in the U.S.S.R. in that year. This is like comparing apples and oranges. The Soviet figure includes *kandidat* degrees not only in science but in all fields of training—including education, arts, economics, Marxism-Leninism, etc.

Q. *Is a Soviet trained physicist, chemist, or engineer as well qualified as his counterpart in the U.S.?*

A. In general, comparing scientific training, there are no significant differences between, let us say, an American Ph.D. in physics and his Soviet counterpart. The difference increases, however, as we go down the academic ladder. At the high school level the science and mathematics content of instruction in the Soviet Union is, statistically speaking, very much greater than it is in the U.S.

Q. *What do you mean by "statistically speaking?"*

A. All Soviet "high school" pupils take one and the same course. He is heavily oriented toward science and mathematics. Thus *every* Soviet "high school" graduate—1.3 million of them in 1955—has had the equivalent of more than four years of high school mathematics (through trigonometry) and nearly six years of high school science.

Q. *How many of the "high school" graduates in 1955 went on to higher education? How were they selected —by aptitude tests, scholastic record?*

A. No more than 220,000 of these new graduates were admitted to the institutions of higher education—perhaps considerably fewer. The present admissions policy is to give preference to older "high school" graduates, those with two or three years of work experience.

A Soviet applicant may apply to only one school in any year. Selection is made on the basis of competitive examinations in several subjects, taken orally and graded subjectively by individual examiners. I do not think this system provides the best means for selecting the most able and promising students.

Q. *What happens to those who don't pass?*

A. In practice they may not get another chance to apply for resident study. Going to work is the obvious alternative. They may then enroll in an extension course of higher education. Another alternative is to qualify for admission to a "technicum," a school for sub-professional training in various fields. Engineering and industrial technicums, with their two-year courses of sub-professional training following graduation from "high school," are similar to U.S. institutes which train engineering technicians. Here is one area of training that the Soviets have been strongly promoting. We estimate that by 1958 they may train at the rate of approximately 140,000 engineering and industrial technicum graduates per year. In comparison the present output of engineering technicians in the U.S. is perhaps not more than 20,000 per year.

Soviet Science Academy Voted Into IAF But Must Still Supply List of Members

Q. *Mr. Haley, what has been your association with Soviet scientists?*

A. My first acquaintance with them was at the Copenhagen Congress of the International Astronautical Federation in 1955. Two Russian gentlemen came in an official capacity, namely Professor Ogorodnikov of Leningrad and Professor Sedov. They listened quietly to the Congress proceedings. Then they agreed to a press conference at the Soviet Embassy which I attended. I can't recreate the acute and searching questioning by reporters but my impression was that the answers were adroit and uninformative. I always have been acutely aware of the problem of re-entry to the earth's surface—of an object, flying in outer space; so, rightly or wrongly, I asked Professor Sedov myself if Russian scientists have studied the problem of re-entry of earth circling satellites back to the earth's surface. He seemed a bit perplexed. So did Ogorodnikov. Their answer was that this sort of question was not on the agenda. Socially, the two professors circulated freely among all people. Nothing was said, that I heard anyway, that had any ideological bearing on the problems of rockets.



They showed no knowledge of rocket techniques either theoretical or in the field of hardware. On the other hand they showed no lack of knowledge. All they showed was that they were not going to give any information. Then at the IAF Congress in Rome last year, I actively sponsored the membership of the Moscow Academy of Science in the IAF. Prof. Sedov was elected vice president. The purpose of the IAF is essentially civilian and peaceful, and in order to be able to have civilian and peaceful earth circling satellites, we need the common consent of all the nations of the world. Certainly we need the consent of a nation which controls one-sixth of the land surface of the world. Therefore, I though it was my duty to insist that the application of the USSR be acted upon favorably by the IAF so that they not only shared the benefits but also the duties and responsibilities.

There were a few remissions in the information they submitted, however. They didn't have a copy of the constitution of their committee. So we want that. Another was that they didn't have a full list of the membership, which we want, and we'll never get such a list if they don't have an official standing in our organization. ★



B. Ellis (center), head of the Propulsion Department, discusses methods of accurate thrust termination for a ballistic rocket with Dr. Howard M. Kindsvater (left), propulsion staff engineer, and André P. Bignon, propulsion research specialist.

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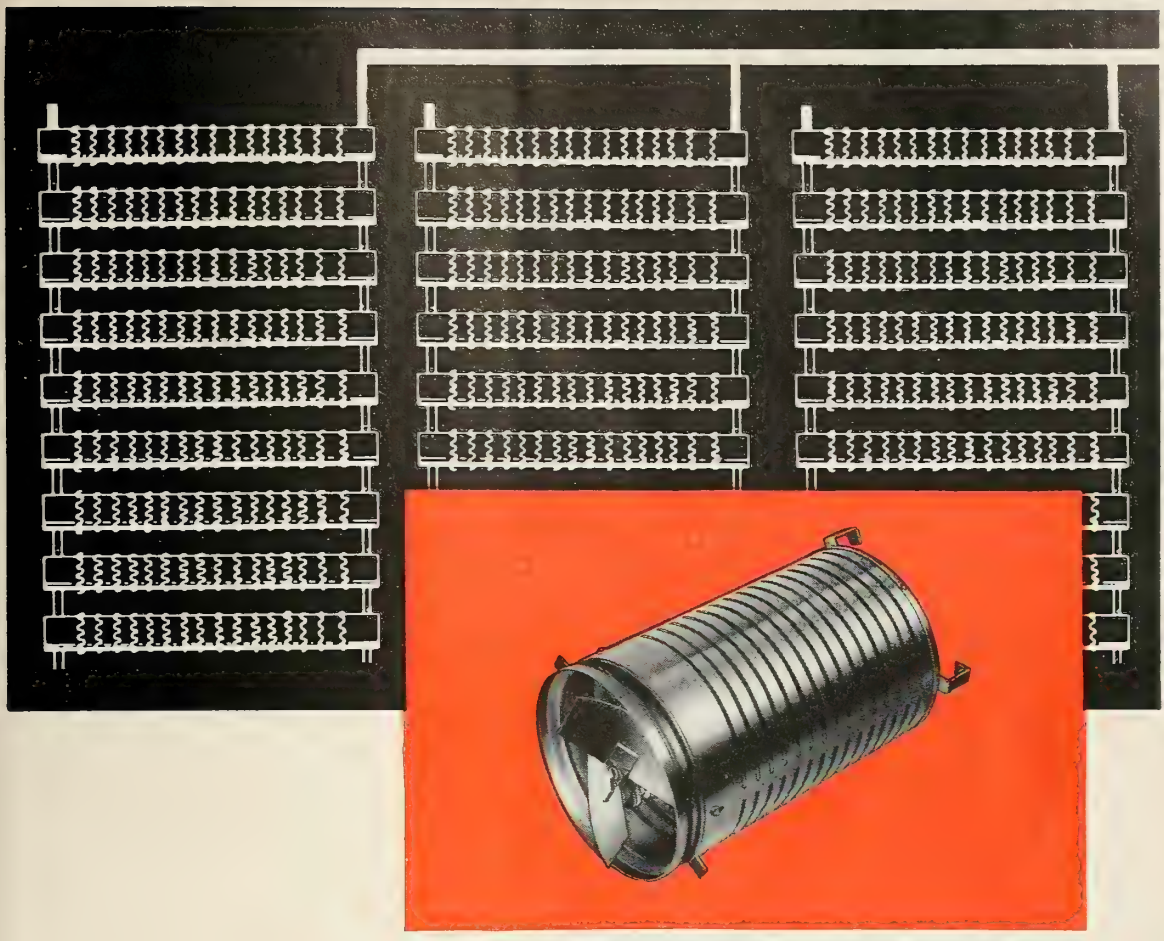
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What the Russians Tell . . . and What They Don't Tell

By Albert Parry
Professor of Russian Civilization and Language, Chairman of the Department of Russian Studies, Colgate University, Hamilton, N. Y.



Exactly one year ago, in February 1956, at the Twentieth Congress of the Communist party in Moscow, the Soviet Defense Minister Marshal Georgi K. Zhukov declared that Russia already possessed "diverse atomic and hydrogen weapons, powerful rocket and jet armament of various kinds, including long-range rockets."

Two months later, on April 23, during his (and Bulganin's) state visit to England, Nikita S. Khrushchev, first secretary of the USSR's Communist party, boasted even more boldly of Red progress in guided missile development. Soon, he said in his speech to the Birmingham Chamber of Commerce, the Soviet Union would have a missile armed with a hydrogen bomb warhead able to hit any spot in the world—meaning, of course, any spot in America first of all.

How soon?

Apparently not yet by the end of 1956. But other, nearer Western countries could by then be reached. "If rocket weapons had been used against Britain and France . . ." warned Premier Nicholas A. Bulganin ominously in his message to Prime Minister Anthony Eden of Britain and Premier Guy Mollet of France on November 5 in connection with the Suez crisis. He threatened to use against England and France, not the Soviet "naval or air forces," but "rocket equipment."

This, by Moscow's official announcement, meant that already three months ago the Soviet Union had means of rocket attack spanning whole nations—if not entire oceans and great continents as yet.

But beyond these statements, threatening or triumphant though they may seem, neither the Soviet people nor the outside world is told by the Moscow leaders precisely what has been achieved in Russian warhead-rocket research and production—exactly how far the guided-missile experimentation of the military type has progressed in the Soviet domains.

Our side tries, naturally enough, to "guestimate" the very latest state of Soviet accomplishments in this crucial field. But the Soviet leaders are no fools. They do not rise to the bait. They make no statements either to foreigners or in their own Moscow press either denying or confirming our intelligence.

In May 1954 George P. Sutton, chief of the Aerophysics Department of North American Aviation, Inc., stated that according to his information the Soviet Model 103, a liquid-propelled rocket engine, weighed very little, yet had the thrust of 53 conventional turbojet engines or more than five times the thrust of the German V-2 rocket. The Red goal, he said, was to evolve a 5,000-mile-per hour guided missile.

Any Soviet reaction to this American revelation? None whatever. Hard as we searched the Moscow press for any comment on Mr. Sutton's statement, there was nary a word.

Symington Reveals Red ICBM

On July 21, 1954, Senator Stuart Symington of Missouri, former Secretary of the Air Force, spoke of the Soviet attempt to produce an intercontinental missile with a hydrogen warhead of 4,000 to 5,000 mile range. Did Moscow acknowledge this declaration with any further clarification of its own? Not at all.

That the Soviet Russians had built long-range guided-missile launching platforms "at dozens of points in Europe and Asia . . . in a pattern allowing an arc of fire to cover, for instance, the Baltic Sea," was disclosed on May 18, 1955, by Representative Overton Brooks, a member of the House Armed Services Committee. Barely a month later, in mid-June 1955, our own Erik Bergaust reported after a trip to Europe that the Soviets had a liquid fuel rocket engine capable of developing a quarter-million pounds' thrust and a missile arsenal "as advanced as it is substantial." But again Moscow's response was, in effect, "No comment."

On February 5, 1956, Senator Symington returned to the theme by pointing out that the Soviet Union had tested an intercontinental ballistic missile which went "hundreds of miles further" than any such weapon then tested by the United States. The Russians, he added, were "well ahead of us." Insisted the Senator:

"I don't 'believe' the Soviets are ahead of us in ballistic missiles. I *state* that they are ahead of us in ballistic missiles."

Any significant echo from Moscow? Mum was still the Red word.

Similarly there was neither "yes" nor "no" from the Reds to other American statements that, late in 1955, the Soviets had missiles with ranges up to 1,500 miles; that by late 1956 these ranges surely increased; that Soviet submarines could fire ballistic missiles over distances of 650 miles when submerged and nearly 1,500 miles on surfacing.

But if not all such things, then just what are the Soviets saying about their rocket research and experimentation?

Mostly they tell their people of *our* guided-missile work and in the process call us nasty names because, the Moscow propagandists repeat again and again, in our rocket experimenta-

tion we mean war only, never peace—and aggressive war, at that, not merely defense.

On March 3, 1956, *Sovetsky Flot* (Soviet Navy), the official Russian navy organ, denounced the latest American development of guided missiles as being "for offensive purposes" and "aggressive plans." The Russian article carried as its illustrations detailed sketches of three American missiles (*Terrier, Regulus,* and *Petrel*) along with data as to their range, speed, weight, warheads, and guidance systems, also the types and names of United States warships being re-equipped for missile operations. Significantly the Soviet navy journal remarked that, of course, such "weapons can be used by both sides"; in other words, that the Soviet Union had such missiles, too.

Lists US Peace Rockets

It is true that the article on *Raketa* (Rocket), in Volume 35 of the Great Soviet Encyclopedia (July 1956), lists two peaceful American missiles along with three military ones, but the general tone of Soviet writers is "Be on guard against that warmongering America, fellow citizens!"

"We must not forget," warns Boris V. Liapunov, a Soviet engineer specializing in writing about missiles and rockets for the layman, "that guided missiles can carry not only scientific-research equipment, but also explosives; not only mice and monkeys, but also atomic warheads." He makes this statement in his article *"Samoliot-Raketa-Snariad"* (Plane-Rocket-Missile) published in the Moscow *Ogoniok* (Little Fire) on May 1, 1955. He does not say anything clear or definite about the Soviet investment and accomplishments in guided missiles. Instead he cautions the Russian reader that "the aggressive circles of the imperialist countries devote considerable attention to guided missiles as a weapon of mass destruction."

In such countries (meaning the United States first and foremost), "guided missiles of most varied types are being planned and tried out for the army, the navy, and the air force." What can or will or do the Soviets undertake to counter this danger from the West? Plenty, hints Liapunov. "Like atomic weapons or any other weapons, pilotless arms have two edges. Rockets and pilotless missiles are in themselves a target for our means of defense."

But will the Soviets attack first? Comrade Liapunov hedges on this a bit: "Soviet people demand prohibition of the weapons designed for the mass annihilation of humans. Science should serve peace and prosperity of mankind. With their pilotless aviation Soviet people will conquer the ocean of air, will study the world's space." His implication is that this Russian conquest will be wholly peaceful, but should any foreign power stand in its way—look out!

Earlier, in 1954, and speaking this time directly to Soviet soldiers, the very same Boris V. Liapunov charged "the imperialists" with the evil intention of "using rocket technology to wipe out people en masse." He issued this warning toward the end of his book *Raketa* (Rocket) published in Moscow in the series "Scientific-Popular Library for Soldiers and Sailors" by the Soviet Defense Ministry. "Modern technology," he wrote, "permits the utilization of rocket weapons over distances of thousands of kilometers, without employing airplanes." But, continued Liapunov, the Soviet armed forces have such weapons, too—strictly for defense purposes, "to give a smashing repulse to the foe in case he dares to aggress." We, the Soviets, also have "scientists, engineers, designers, and industrial specialists" in this newest field!

Explaining to the Soviet soldier and sailor the scientific principle of Soviet "defensive" guided missiles, Professor Kosmodemiansky closes his recent book with this eloquent appeal:

"Warriors of the Soviet army, navy, and air force! Remember that these days science stands beside you in defending the frontiers of the Socialist Power. Think as you create and improve your fighting technology. Daydream, indulge in fantasies; then check your daydreams and fantasies by mathematical calculations and practical experiments. Always bear in mind the proud motto of Constantin Eduardovich Tsiolkovsky: *That which is impossible today will become possible tomorrow!"*

In many such Soviet books and articles the "glorious" tradition of the use of rocket weapons by the Russian armed forces is continually stressed.



Soviet Guided Missile Czar—
Air Marshal Zhigarev

By text and picture it is recalled that Russian military commanders and engineers first introduced rocket artillery in their wars of the early 19th century; that Russian inventors constantly perfected such weapons; and that under the Soviets, in World War II, the celebrated "Little Kitty" (*Katiush*) or modern rocket artillery truly distinguished itself.

In their discussions of rockets and missiles of other than military nature, Soviet writers like to dwell again and again on the pioneering work of Tsiolkovsky and other Russian professors of the first 30 years of this century. They also boost the "boomerang-to-the-Moon" project of our contemporary Professor G. Chebotarev. They revel in detailed descriptions of the artificial satellite of the Earth soon to be launched by the Soviets; also in the blueprints of Soviet mail-service by rocket, and in other such peaceful accomplishments or plans.

In their book *Samoliot-Raketa* (Rocket Plane) published in Moscow in 1953, L. K. Bayev and I. A. Merkulov praise not alone Tsiolkovsky but also such pioneers as F. A. Tsander and Yu V. Kondratiuk. These Russian researcher-inventors are lauded in the little volume for their suggestion "to utilize as fuel for rocket engines such metals as magnesium and aluminum . . . by burning them in oxygen or by combining these metals with the chemical element of fluorine, this leading to a great yield of heat energy." The authors point out that "this enhances the energy of the fuel and, besides, allows to burn, toward the flight's end, those parts of the flying apparatus which by then would become unnecessary anyway." Soviet readers are informed that here lies the solution of the problem of how to increase sharply the range of flight.

No Manned Satellites

Lucid explanations of Professor Chebotarev's project of sending a rocket to the Moon and back have been appearing in the Soviet press quite frequently, the best of these having been presented in *Literaturnaya Gazeta* (Literary Gazette) of October 20, 1956, and *Trud* (Labor) of September 30.

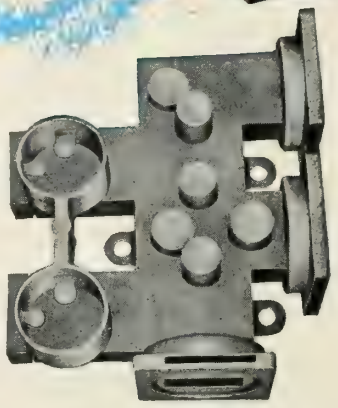
In effect cautioning the Soviet reader against too much optimism, G. B. Kozhevnikov (an engineer) wrote in his treatment of radioelectronics and the artificial satellite in *Radiotekhnika i Elektronika i Ikh Tekhnicheskoye Primeneniye* (Radiotechnology and Electronics and Their Technical Application, Academy of Sciences, Moscow, 1956) that it was far too premature to expect the actual manning of the satellite with human beings. "Mod-



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ern rocket means now available," he remarked, "do not yet permit us to launch a satellite large enough to lift into space one or more men."

On the other hand, Yu. Khlebtsevich (a candidate of technical sciences) showed considerable confidence in the prospects of rocket work in Russia when in his article on the artifical satellite, published in *Literaturnaya Gazeta* on July 10, 1956, he maintained: "We must note that from the viewpoint of modern technology the launching of an artificial satellite does not present any particular complexity. In the future, satellites will set out on their flights by the score—to various heights, along different orbits."

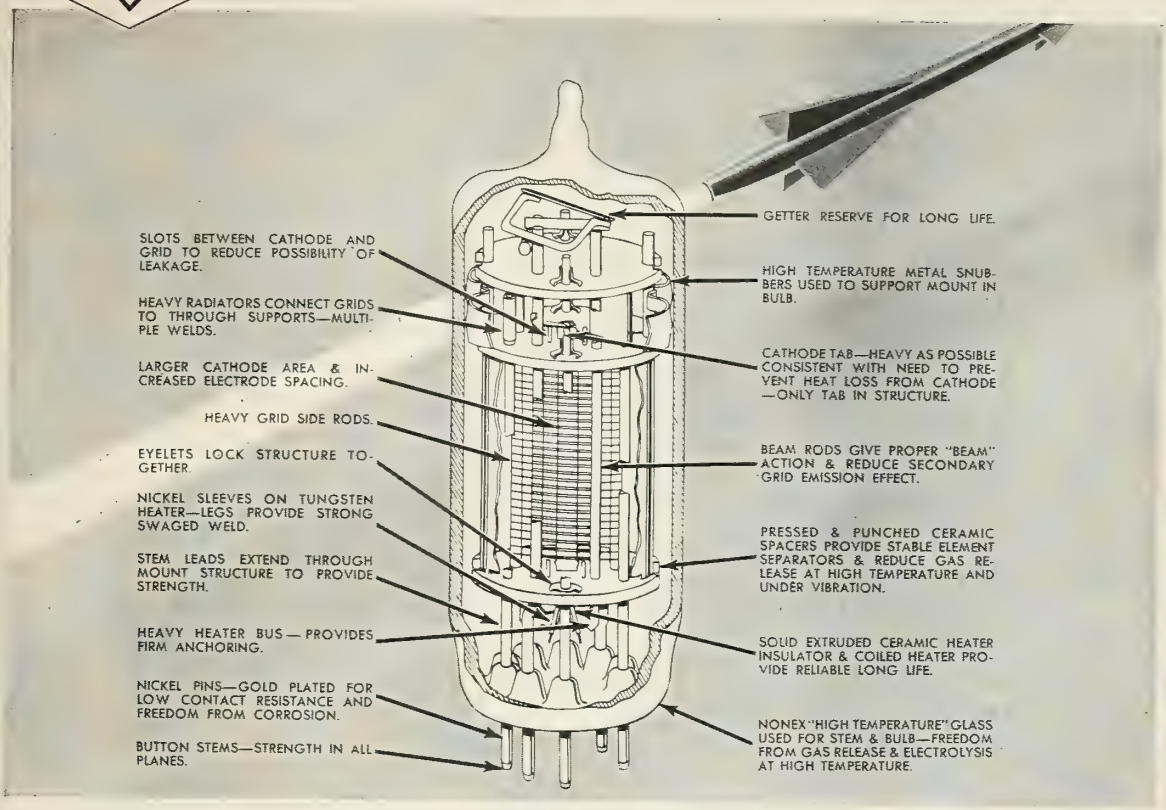
Speaking of what may prove actually practical in the very near future, Liapunov in his already quoted *Ogoniok* article discourses on Soviet postal-service rockets. He makes a point of insisting that such mail-rockets are "no idle fantasy." The Red project of such mail service, he says, is based on "the entire experience of rocket technology, in cooperation with radiolocation and automatics already creating remarkable pilotless machines flying faster than sound." Postal rockets are planned to connect Moscow with the farthest cities "of the European part of the country." Soviet Asia will evidently have to wait for such boons. No more than one-half hour will be needed to reach, by postal rocket, the farthest European Russian city from the Soviet capital. "The sending of a letter will most likely cost not more but less than it does now, yet think of the tremendous time gain!" exclaims Liapunov. To his text he appends a drawing by N. Grishin, a Soviet artist, showing the landing of a mail-rocket of the future.

In another of his numerous texts —in his 1954 book *Raketa*—Liapunov predicts an equally early use of rockets for shipping freight "from one end of the country to another in a matter of just a few hours." Here Soviet Asia is included—else the time lapse would have surely been stated in minutes.

And in his 1955 volume entitled *Rassakzy o Raketakh* (Tales of Rockets) the same author become eloquent about Soviet peaceful progress to the point where he proclaims that "we have never had and could not have rockets that would serve as means of destroying of a mail-rocket of the future.

Here the Red signals have certainly become crossed. How this peaceful use of warlike rockets could be possible, in view of all the statements by Khrushchev, Bulganin and Zhukov about Soviet possession of warhead-carrying guided missiles, only the main Moscow propaganda office in charge of Liapunov's writings can figure out. ★

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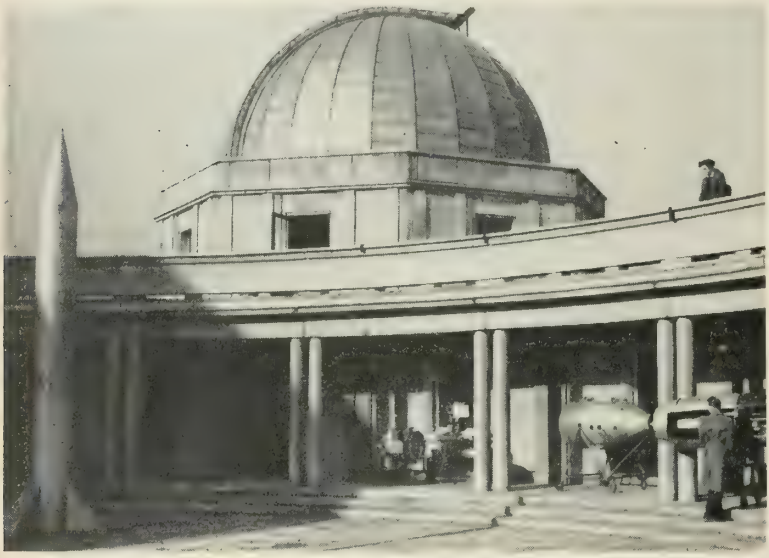
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6384	6AR6 6098	6AR6	6.3	0.9	T-11	TE-27
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6486A	6486	6AS6	6.3	0.25	T-6½	TE-43
6582A	6582	6AK5	6.3	0.25	T-6½	TE-44
6754	412A	—	6.3	1.0	T-6½	TE-36
6851	5751	—	6.3	0.5	T-6½	TE-42
6877	—	Half of 6080	6.3	0.8	T-6½	TE-48
6900	5687	5687	6.3	0.9	T-6½	TE-54
6889	—	—	6.3	0.9	T-11	TE-52
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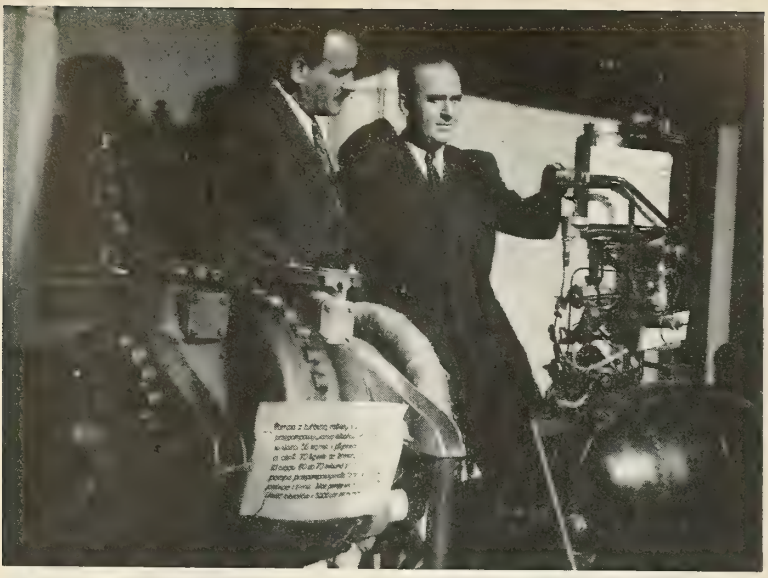
Behind-Iron-Curtain Rocket Show



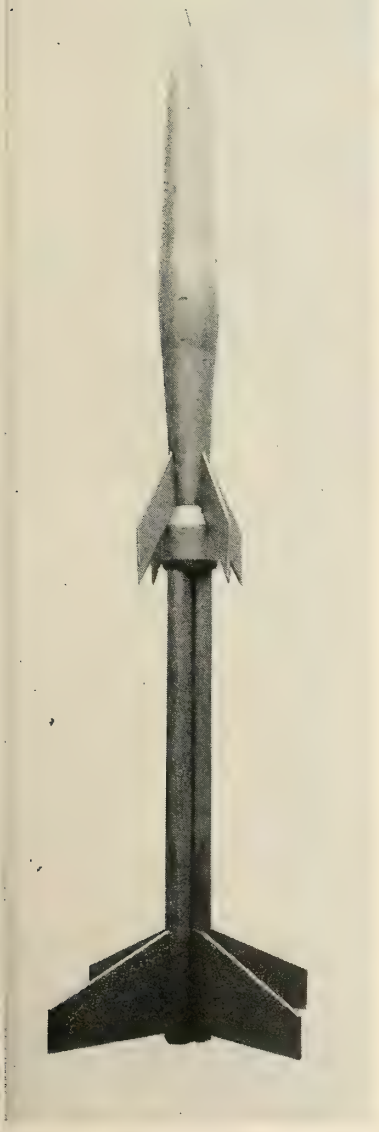
The Silesian Planetarium and Astronomical Observatory in Katowice in Poland has been the home of a recent rocket and space flight exhibit sponsored by the Polish Astronautics Society in cooperation with the Museum of Technique of the Chief Technical Organization NOT. Several German and Russian items were displayed. Of particular interest was a modified Russian T-7A research rocket (left) which is believed to be of the size and have the performance of our Honest John.



Director of the Silesian Planetarium, Professor Satabun, right, is posing in front of picture of space man with Wladislaw Geisler, physics engineer and president of the Silesian Section of the Polish Astronautics Society. Geisler was a delegate to last year's International Astronautics Federation Congress in Rome, Italy.

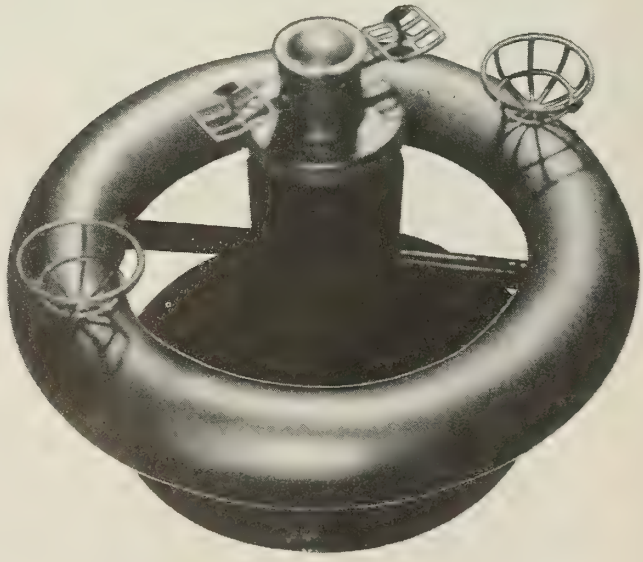


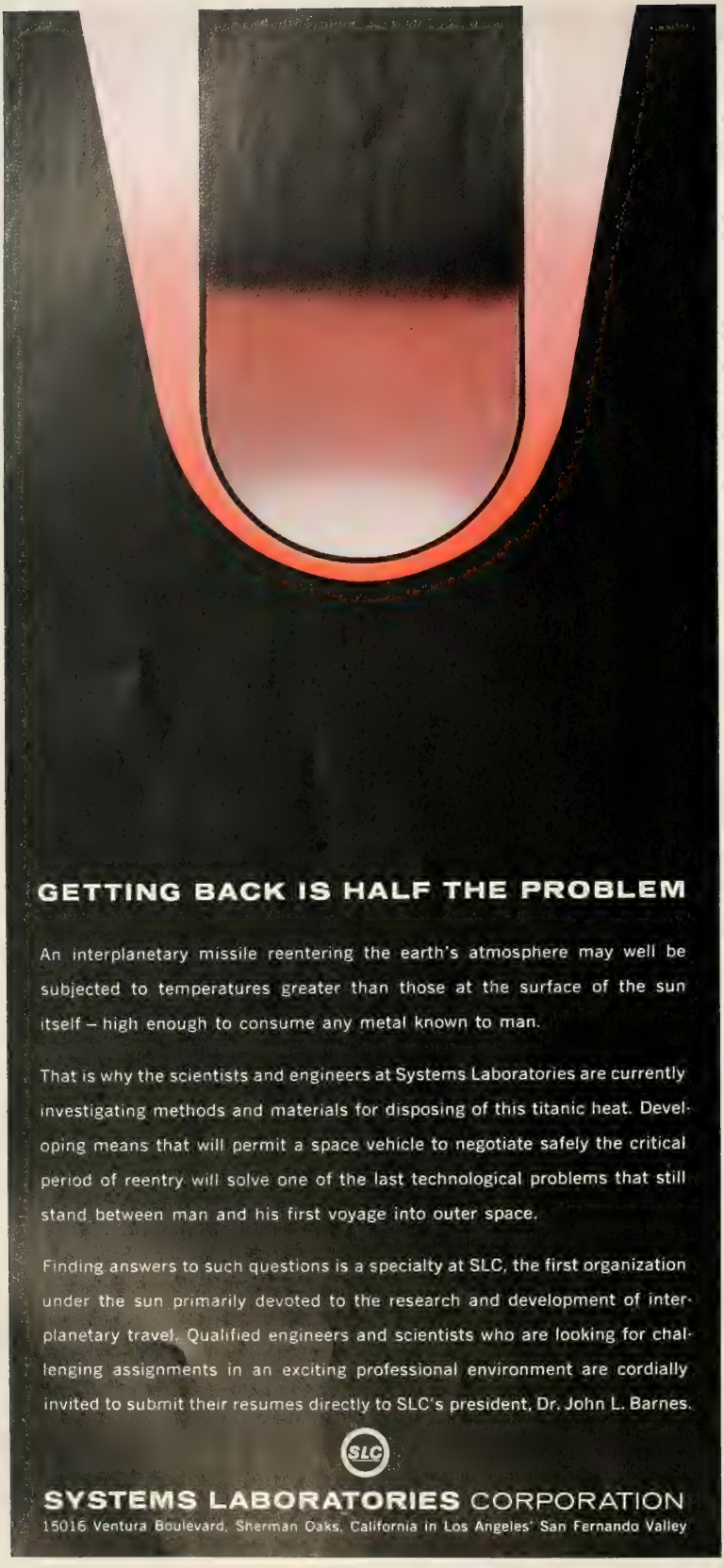
Satabun and Geisler looking over V-2 components. Main pump and turbine unit (left), and gas generator are displayed. Undamaged, well-maintained equipment and components were contributed by the Russian Army. They were shipped from Soviet missile schools. Numerous research rockets also were provided by Reds.



Russian Mach 4 sounding rocket. Notice crude first-stage booster and fixed stabilizer fins. Booster consists of four solid-propellant chambers believed to be modified aircraft rockets. Odd-size second stage contains instrumentation and small parachute. Reports say Russian research rocketry is extensive. Large rockets have carried animals to 300 miles, Reds say.

Model of Russian space station, similar to Wernher von Braun's famous "pinwheel." Interest in astronautics is overwhelming, according to Geisler. He told m/r the exhibit has been visited by more than 20,000 in less than four weeks. Exhibit is now touring Poland and might also go to other satellite countries.





international briefs

USSR Aviation Minister Honored

P. V. Dementyev, minister of the aviation industry in the U.S.S.R. has received one of the highest awards of the Presidium of the USSR's Supreme Court. Dementyev received the Order of Lenin on his 50th birthday "for his services in aviation industry development."

Supersonic Atom Plane Design Shown by British Firm

The British company, Hawker-Siddeley Nuclear Power Co. has published general details of its version of a supersonic nuclear powered aircraft in the Hawker Siddeley Review, a company house organ. Though, the general design is too heavy for missile application, it is a first step in the direction of a nuclear rocket. Noting that low weight and space are essential, the article says:

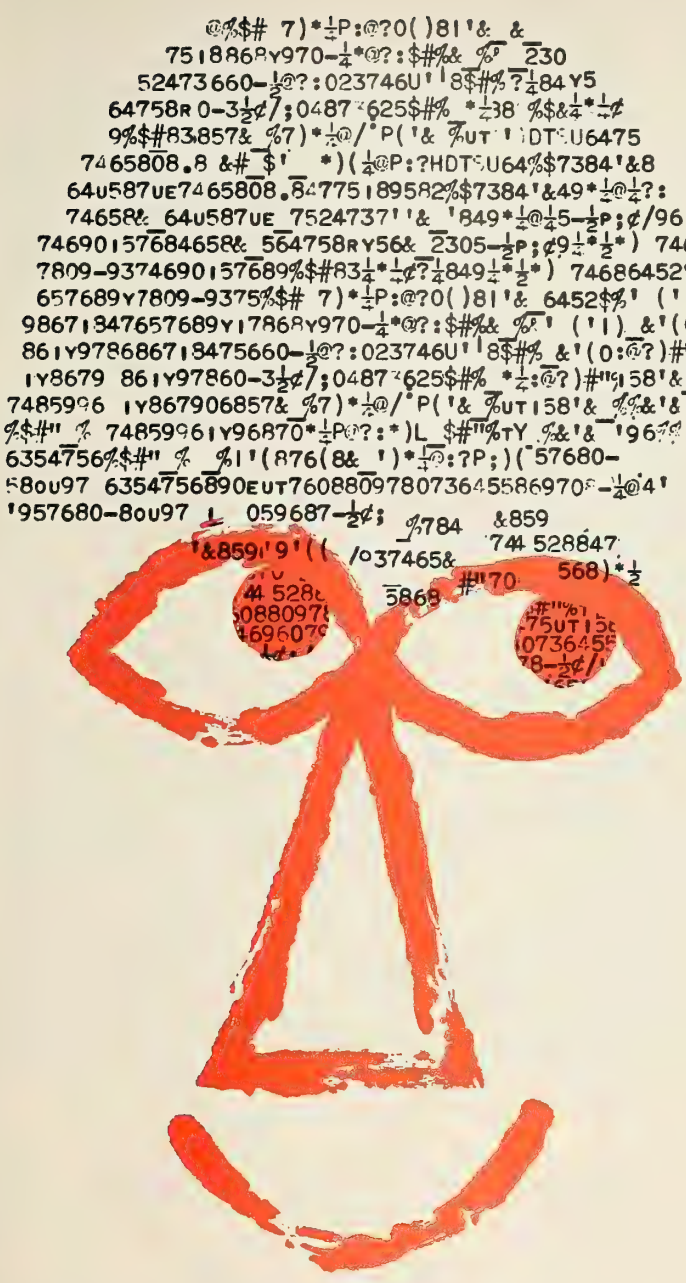
"At present a fast reactor with highly efficient liquid-metal heat extraction would seem the most suitable system, although there are strong arguments in favor of a gas-cooled system even at the expense of some increase in size. The crux of the aircraft problem is a successful evolution of the concept of partial shielding but, even so, such aircraft will be large with all-up weights probably greater than 100,000 pounds."

The Hawker-Siddeley configuration shows two wing-tip turbines driven by a reactor situated about amidships in the fuselage.

Britain Schedules Testing Of Skylark Rocket

Test firings of Great Britain's upper atmosphere research rocket is scheduled soon at Woomera. The *Skylark* is 25 ft. long, 17½ in. diameter and is stabilized by three swept fins. It is powered by a Bristol Aircraft Raven dry rocket, which has a maximum thrust of 11,500 lbs. for a nominal 30-sec. period.

The initial design ceiling is 70 miles with 120 miles foreseen for later variants. The launching tower at Woomera will be 80 ft. high and once a predictable trajectory has been proved, firings will continue from a similar tower at the MoS missile center of Aberporth, Wales.



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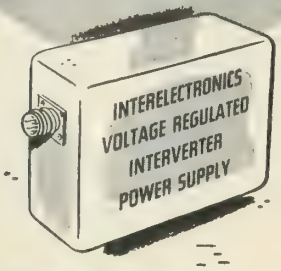
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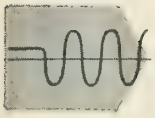
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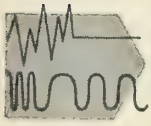




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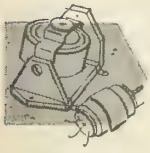
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International Scene



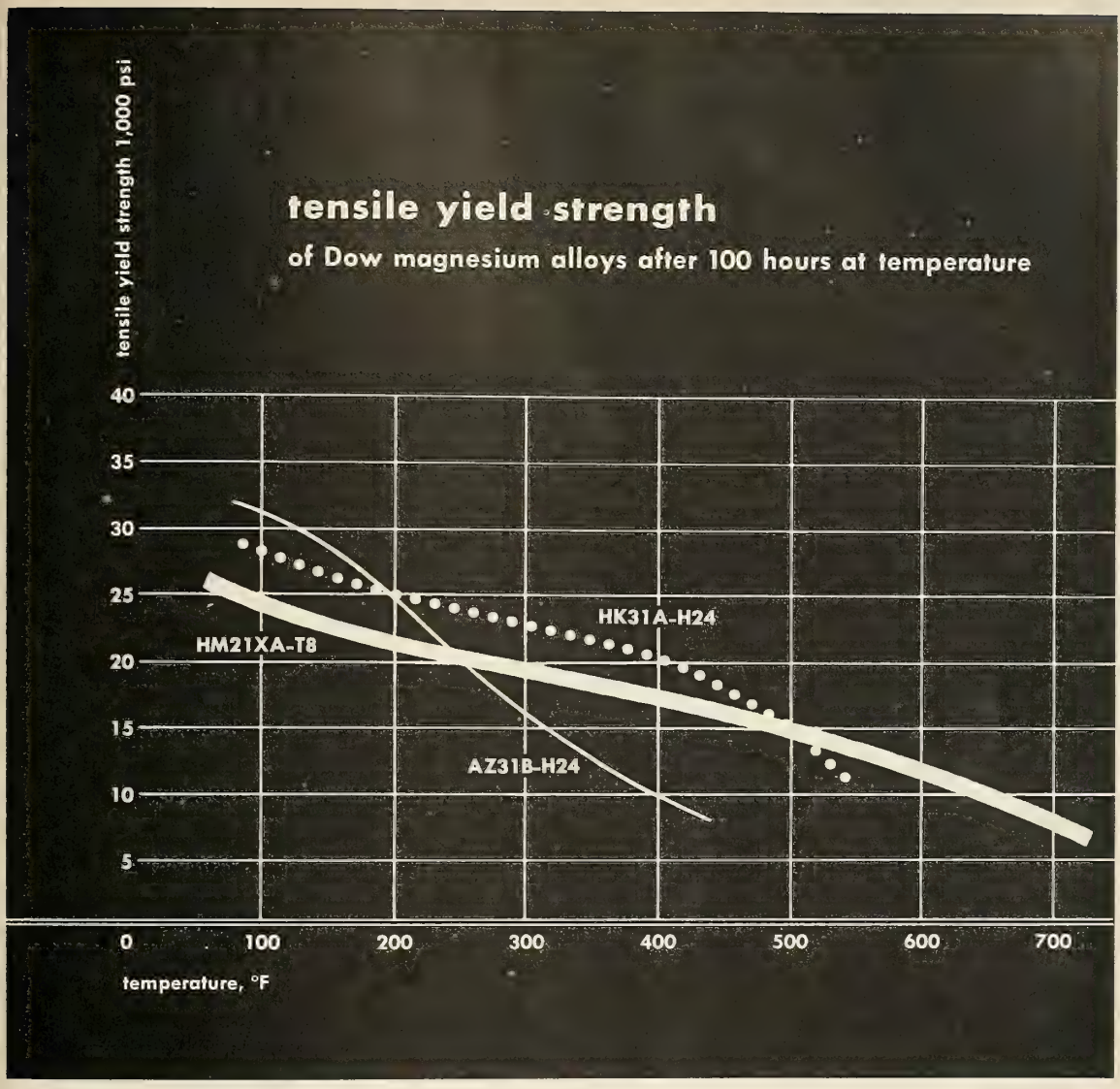
By Anthony Vandyk

None of the group of reporters, including this writer, who visited Russia last year saw any trace of Soviet missile activities. It was some consolation to learn that General Twining did no better. "We met a blank wall," he said. Nonetheless, Soviet aircraft production methods can give a clue to missile production techniques. Three things about Soviet aircraft production methods impressed the Twining group. First, the assembly jigs were light and simple; in contrast with the American practice of employing forgings or extrusions, welded sections were used for landing gear and similar structures. Second, curved sections were fabricated from sheet aluminum on simple hand-operated light hammers, while more difficult sections were formed by air-activated, hydraulic stretch processes managed by simple hand control. Third, the wing and fuselage sections in the plant visited by the Twining group were built up by the riveting together of smaller parts.

The two plants to which the Twining group was permitted were among the oldest in the Soviet aircraft industry and are not representative of the modern production facilities that exist elsewhere in Russia. Nonetheless, says Twining, there is good reason to believe, even on the basis of these two examples, that the Soviet Union possesses "in high degree the ability to apply mass production processes and techniques to the manufacture of airframes and jet engines." In research facilities the Russians seemed to Twining to be doing well. At the Zhukovski Air Engineering Academy the Twining group was given a demonstration of a Mach 3 wind tunnel. The aircraft model used was a true delta design. From the shock waves produced when it was subjected to the ultrasonic air stream, "it was clear that this tunnel was a bona fide Mach 3 testing device," Twining reports. There was another wind tunnel at the academy which the Russians said should produce Mach 5 conditions but this was not put into operation for the American group.

During a visit to the Air Force Academy at Monino the Twining group noticed several models of U.S. aircraft in a classroom devoted to the study of fighter tactics. Among the models represented were the B-52, F-100, F-101 and the B-66—but no missiles. This writer saw photographs of the Matador and the Regulus in the Air Museum in Moscow but there was no material whatsoever on Russian missiles. During the fairly extensive travels of the group of reporters accompanying General Twining no missiles or apparent launching sites were observed. The reporters were allowed to travel freely in the Moscow area and many numerous flights on commercial aircraft to and from the Soviet capital. It is probably that the aircraft use air corridors that avoid areas of special military interest. Nonetheless, it is amazing that not a single missile or launching sight has ever been detected by a Western reporter, particularly since many reporters and other observers have seen Russian radar installations.

The Russians' missile potential is of vital interest to the Western world at a time when Britain is planning to cut its defense expenditure and concentrate most defense production on a long-term missile program which is unlikely to show any results before the end of this decade. At this writing it seems that the U.S. will have to defend the western world with missiles for several years to come, either directly with missile-equipped units based in foreign nations or indirectly by supplying the armed forces of NATO allies with U.S.-built missiles. The possibility of extending the off-shore procurement to the missile field exists but it does not seem to offer a satisfactory solution to the problem of bolstering the overall missile defense of the western world in that many of Europe's present missiles are inferior to their U.S. counterparts.



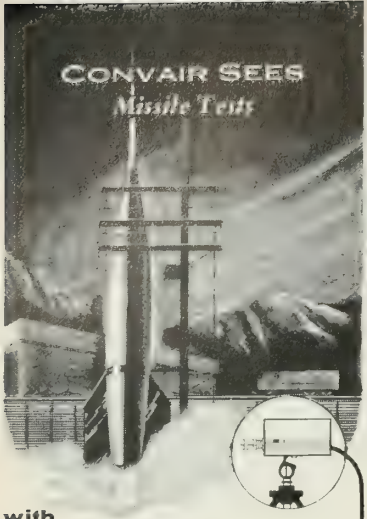
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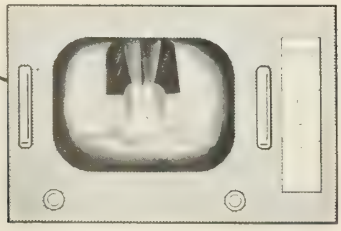
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World Astronautics



By Frederick C. Durant III

During the past few years the press has reported the conflicting claims of the U.S. and the U.S.S.R. as to which nation fathered certain major inventions, e.g. the airplane and the electric light bulb. With respect to the science of astronautics, however, there appears to be no argument: Russian K. E. Tsiolkovski was the founder.

It was Konstantin Eduardovitch Tsiolkovski who, in retrospect, most completely realized the relationship between rocket propulsion, mass, and the distances from the earth to other heavenly bodies. Tsiolkovski, a school teacher, published in 1895 his first article on space flight. He was then 38 years old. Until his death 40 years later he dedicated his life to the careful study of the problems he prophetically realized would have to be solved before man could venture into space. Striving for the highest possible specific impulse he sketched in 1903 a rocket ship showing space for liquid oxygen and liquid hydrogen tanks and a sealed, pressurized crew compartment.

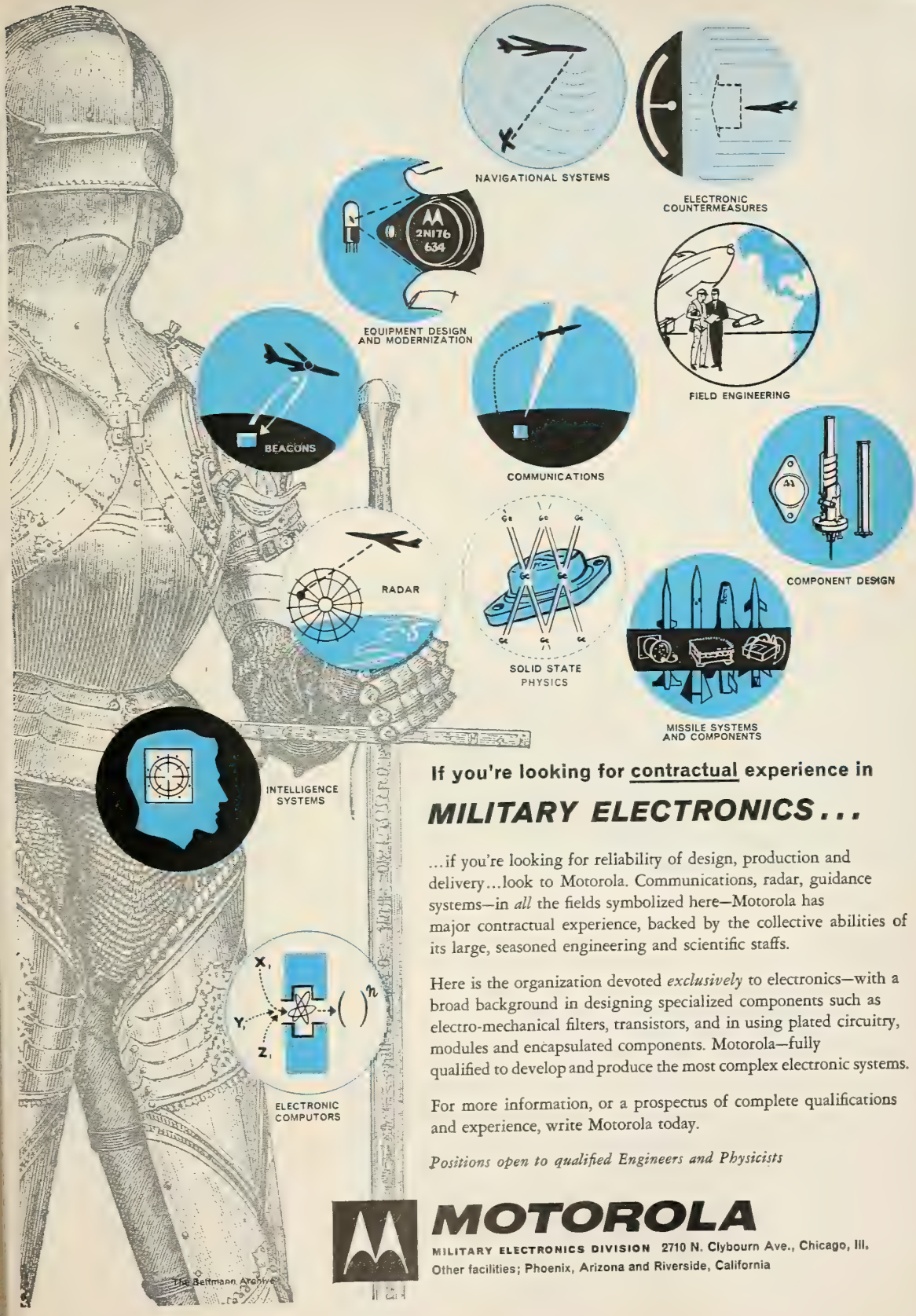
In 1929 Tsiolkovski's disciples Fortikov, Rynin and Perleman founded a competent scientific organization for investigating and systematically developing rocket devices. Called the "Group for the Study of Reactive Motion" (GIRD), chapters were formed in Moscow and Leningrad. In 1934 the Soviet Government organized a military rocket research program which paid off in World War II in rocket bombardment weapons, notably the Katyusha. Since the War there has been increasing reference to rockets and space flight in the official press.

The U.S.S.R. was the first major nation to give official scientific recognition to astronautics establishing in 1954 the Tsiolkovski Gold Medal Award for the "best papers by Soviet scientists working in the field of astronautics." A permanent Commission on Astronautics of The Academy of Sciences, Moscow, was announced in 1955. The Academy is the top scientific body of the U.S.S.R. The Commission on Astronautics was the first governmental organization to apply for membership to the International Astronautical Federation which has as members the rocket and space flight societies of twenty other nations.

The Commission on Astronautics is headed by well-known Academician L. I. Sedov and the membership includes the names of outstanding physicists such as Peter L. Kapitsa as well as engineers and astrophysicists. This public and professional recognition of the respectability of astronautics by the U.S.S.R. predated such recognition by the governments of all other major nations.

At the Barcelona meeting of the IGY national committees last September, Professor Bardin, speaking for The Academy of Sciences officially announced the existence of a Russian satellite vehicle project for the IGY and a desire for cooperation in the U.S. satellite program.

Many rocket engineers fired by the realization that manned space flight could occur in their lifetime even hope for a friendly rivalry and "space race" between the U.S. and the U.S.S.R. Based upon the technology of long range ballistic missiles such research in the upper atmosphere and beyond could result in major breakthroughs in science. Many kinds of data obtainable from rocket research in space can be obtained in no other way. The possibility of military-developed hardware of both countries being eventually used for such peaceful and productive endeavors is an exciting premise.



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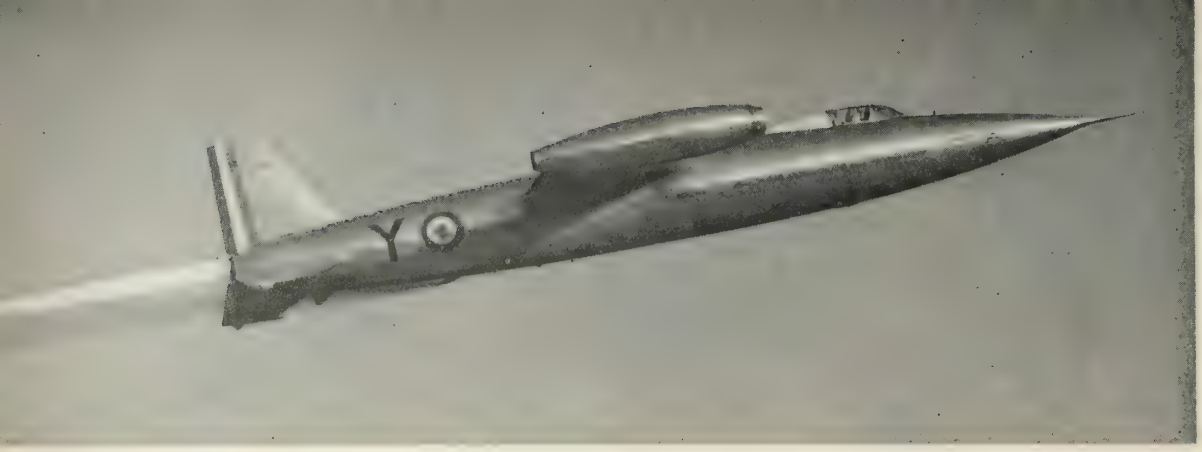
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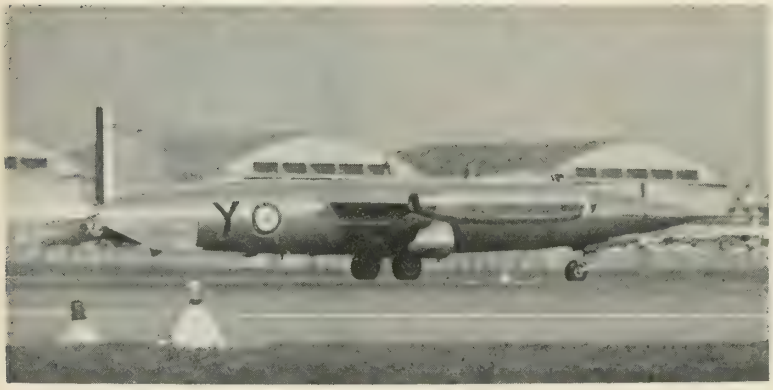
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Ouest-Aviation's TRIDENT I is capable of Mach 1.6 at 53,000 ft. Its SEPR rocket motors provide a total thrust of 9,900 lbs. The wing-tip mounted turbojets are used principally for take-off. The rocket units are manufactured by Societe d'Etude pour la Propulsion a Reaction.

French Solid and Liquid Rockets



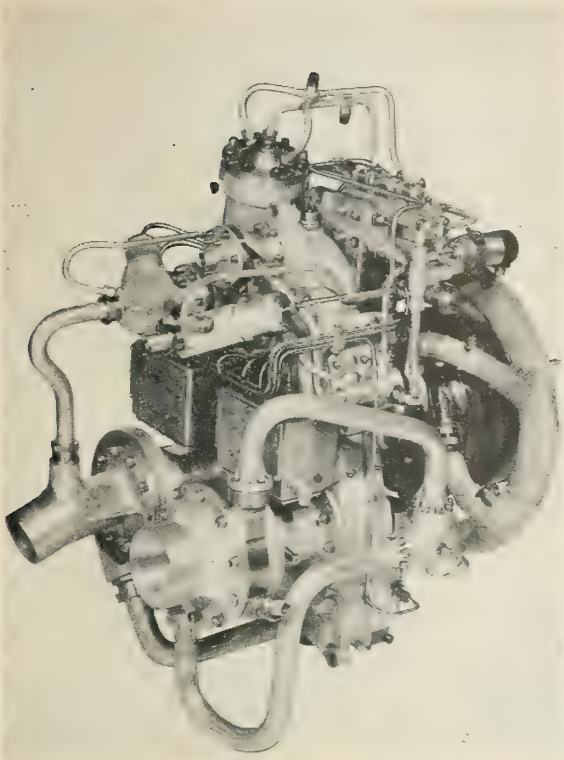
One of the TRIDENT I's three rocket motors is in operation as the aircraft taxies into position for take-off. Overall aircraft configuration is clean, fast.



Tail view of the TRIDENT II shows two rocket chambers. TRIDENT I had three chambers.



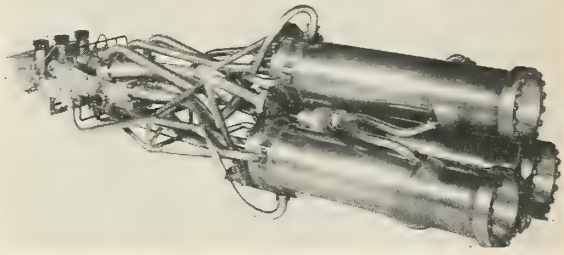
The SEPR-73 solid propellant booster rocket develops a thrust of 45,100 lbs. for four seconds. Loaded weight is 1,528 lbs. Combustion chamber pressure is 995 lbs. per sq. in.



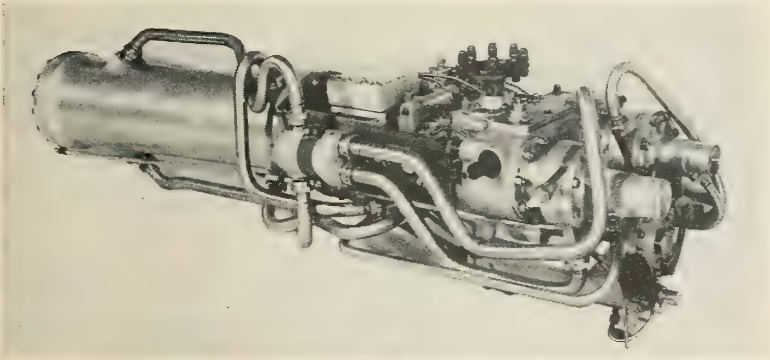
This turbopump unit is used in the TRIDENT I's SEPR-481 rocket engine. Unit operates on rocket engine propellants (nitric acid and furaline). Turbine cooling is achieved by separate water supply.



The SEPR-505 solid propellant booster rocket has a thrust of 22,000 lbs. for 4.5 seconds. Weight loaded is 884 lbs. and overall length is 7.9 ft. Chamber pressure is 780 lbs. per sq. in.



This cluster of three SEPR-481 rocket motors is used in the TRIDENT I. Each chamber develops 3,300 lbs. thrust. The 9,900 lbs. total thrust is about 40% greater power than the 6,000-lb. thrust Reaction Motors engine used in the Bell X-1 and the D-588 research planes.



This is one of SEPR's early rocket engines, the SEPR-25 Guepe used for the Ouest Aviation 6025 Espadon experimental aircraft. Developing 3,300 lbs. thrust, the SEPR-25 uses nitric acid and furaline as propellants which are forced into the combustion chamber by a pumping system mechanically driven from the main powerplant of the Espadon, a Rolls-Royce Nene turbojet. Power take-off arbor is located on top (note attachment plate with eight bolts).

Ouest-Aviation's 6025 Espadon was the first French aircraft with rocket power. The SEPR-25 rocket engine of 3,300 lbs. thrust enabled the aircraft to achieve Mach 3 and an altitude of 50,000 ft. Slung under the fuselage is a Rolls-Royce Nene.



Case For Jelly-Propellants

A jellied propellant has the advantage over a liquid since, with proper pumping and feed design, it can be flow-regulated. At the same time, by this regulation of flow mixture-ratio can be changed and throttling rocket chambers can be built. How can a jellied propellant be obtained?

Various organic substances such as the butyl rubbers, various stearates and such gellatinous substances as the saturate amines which have the property of becoming a quasi-solid under the proper conditions of temperature and pressure may be considered. Various metallic additives, such as metallic soaps, have been added to gasoline and have resulted in the jellification of gasoline.

The cresyl and butyl and buna rubbers again have this property and if the rubber producing reaction is not carried to completion but allowed to stop before full polymerization occurs, a jelly rather than a liquid or solid results.

These jellies could be used as fuels but the problem is to produce an oxidizer which is also a jelly. This is much more difficult since ithe chemically active nature of oxidizers is an inherent block to jellification. One approach out of this dilemma is to combine the oxidizer and the jellied fuel in some way without reacting. This seems difficult since the oxidizer naturally wants to react with the jellied fuel.

The way out of this is to put a third additive into the system, i.e. make a three component system and the third additive will then insulate, so to speak, the fuel from the oxidizer, or as the globule of fuel is surrounded by a layer of liquid polyethylene or some saturate fluorinated liquid elastimer, which prevents the oxidization of the fuel. If this mixture is forced into the rocket thrust chamber, and ignition is applied by a spark or igniter, the insulating wall momentarily breaks down and allows the reaction to proceed. Since the jelly is very temperature sensitive and will readily become a liquid, the reaction proceeds in a liquid phase, and goes to completion. Once the proper temperature gradient is established, all the jellied "mono-propellants" continue to react as fast as the fuel can be injected.

The feed systems for jellies, perforce, are more complicated than for liquids since the "fluid" flow friction is so much higher. Many systems using jellies tend to have, therefore, a somewhat more powerful gas generator and thrust chamber machiners to pump an equivalent mass flow of propellant. Special chamber design would have to be employed and conventional valve pintles and seats would be necessary.

However, an interesting benefit of jellies is the greater unit volume density which is obtained, i.e., more propellant can be packed in a given space. Another advantage is that the absorption of a pressurized gas, such as nitrogen, is reduced again because of the greater density of this jelly. Also, as stated before, since it would be almost mandatory to include the oxidizer in the jelly suspensoid, a form of mono-propellant is obtained. This would more than overcome the extra pumping and piping complexity needed for the jellies since the flow system itself is naturally simpler for a mono-propellant. Boron or berrylium or aluminum as metallic additives would greatly increase the combustion volume temperature.

A drawback of the jelly propellant is its temperature sensitivity. If the temperature were raised beyond the critical point, the jelly might become liquid and create a serious hazard. Therefore, some means would have to be found either by chemical additive or temperature conditions to prevent this recurrence.

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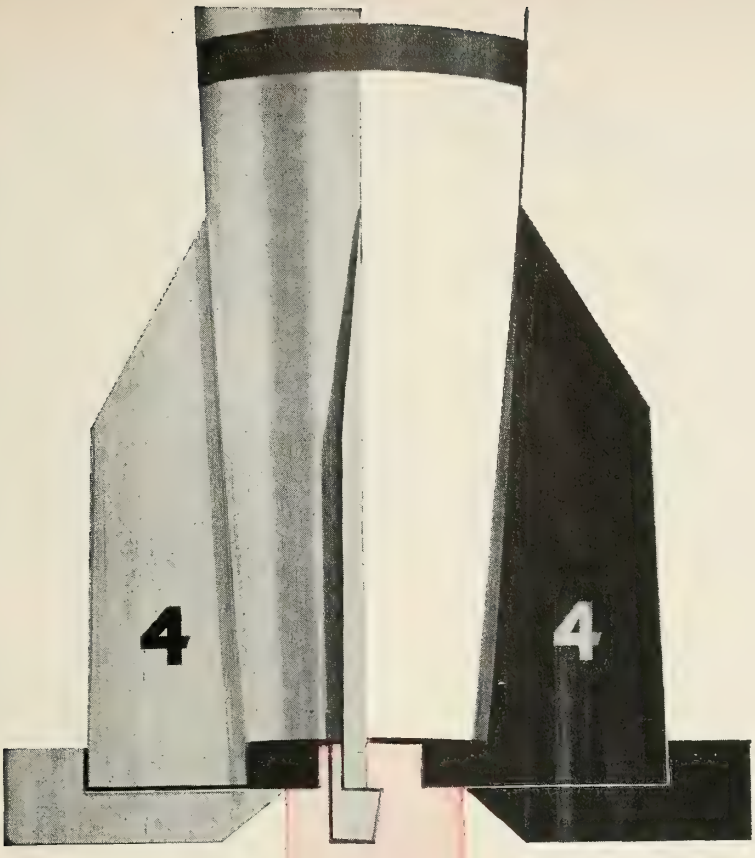
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Aeroballistic Forecasting at Redstone

for High-Punch Missiles

Predicting the influence of natural farces upon giant guided missiles is the difficult job performed by the Aeroballistics Laboratory of the Army Ballistic Missile Agency.

These 20th Century seers would put to shame the Merlins of the past. Instead of crystal ball or occult lore, they employ mathematical equations, meteorology, physics and other sciences to come up with estimates and not guesses.

Heading up this enterprise is Dr. Ernst D. Geissler, whose closely knit team of specialists at this Army Ordnance activity includes 110 civilians and 22 military personnel. Six of them have doctor's degrees in one of the sciences, 20 have master's degrees and 44 are bachelors of science.

Their unique assignment is to forecast the behavior of such missiles as the 60-foot *Redstone* as it roars through the earth's atmosphere and coasts through outer space, then falls upon the target.

"Our predications have so far been quite successful," Dr. Geissler admits. "No change was necessary in the configuration of the *Redstone* due to unexpected aerodynamic characteristics."

Having brought the medium range *Redstone* guided missile to the production stage, the Army Ballistic Missile Agency is now pursuing development of the intermediate range ballistic missile, or IRBM, dubbed the *Jupiter*. This will travel approximately 1,500 nautical miles and can be launched from land or sea.

The Laboratory's success has saved time, materials, and countless dollars. Because of the information developed by Dr. Geissler's group, the Army can hold down the production of test missiles and models to relatively modest numbers. It was for lack of dependable information that the Peenemüende group in Germany was able to launch successfully only 40 per cent of the V-2 rockets developed in the closing phase of World War II.

Dr. Geissler was a member of the Peenemüende group. He was engaged in missile activity since 1940. The year before that he received a master's degree from the University of Dresden and immediately became assistant professor of the Institute for Physics. At Peenemüende he studied the theory of control and stability of guided missiles. When the anti-aircraft missile *Wasserfall* was under development he directed the study of flight mechanics, theory of control and homing.

With his associates he worked out a new method of automatic, three-dimensional homing still in use in ground-to-air missiles. This project won him a doctorate in engineering in 1951.

Dr. Geissler came to the United States in 1945 with Dr. Wernher von Braun and others of the Peenemüende scientists. For the last six years he has concentrated on the *Redstone* missile. He recently became an American citizen.

It takes a well-seasoned mixture of theory and test data to produce reliable predictions of missile behavior. In Dr. Geissler's words, it involves:

"The prediction of aerodynamic lift, drag, stability, pressure distribution, controllability, and forces acting upon missile control vanes for new models is usually based upon a judicious mixture of direct theoretical calculations and extrapolation from existing test data for similar configurations when this information is available."

He added that so far, in the progress of the *Jupiter* program, there has been substantial agreement between the estimates of his Laboratory and results of actual test firings.

ABMA employs the services of many other mathematicians and physicists in the aeroballistic phase of its effort by contracting projects. Thus it derives data from wind and blowdown tunnels, and ballistic ranges, located at Aberdeen Proving Ground, Md., an Army Ordnance installation; the Naval Ordnance Laboratory at White Oak, Md., the Arnold Engineering Development Center at Tullahoma, Ala.; Langley and Wright Fields and Lewis Flight Laboratory of the Air Force; Cornell Aeronautical Laboratory, the University of Alabama and California Institute of Technology.

In many cases Dr. Geissler's personnel provide the models and model balances required for tests conducted elsewhere. Usually his representatives participate in the actual testing.

At the Army Ballistic Missile Agency Dr. Geissler has facilities available far superior to those used at Peenemüende. There is a supersonic wind tunnel, for example, and a high pressure jet facility with ranges from Mach 1.5 to Mach 4.5. He considers this wind tunnel a most efficient tool for obtaining aerodynamic data quickly. Installed in the tunnel are strain gage balances and pressure pickups which flash their information during testing through an analog-digital conversion device to an electric typewriter, or through other circuits which punch IBM cards for interpretation later by a massive computer.

Shortly the Laboratory will begin preliminary tests on a transonic and supersonic test section, double the size of the present tunnel, which will be capable of Mach numbers corresponding to speeds of more than 4,000 mph.

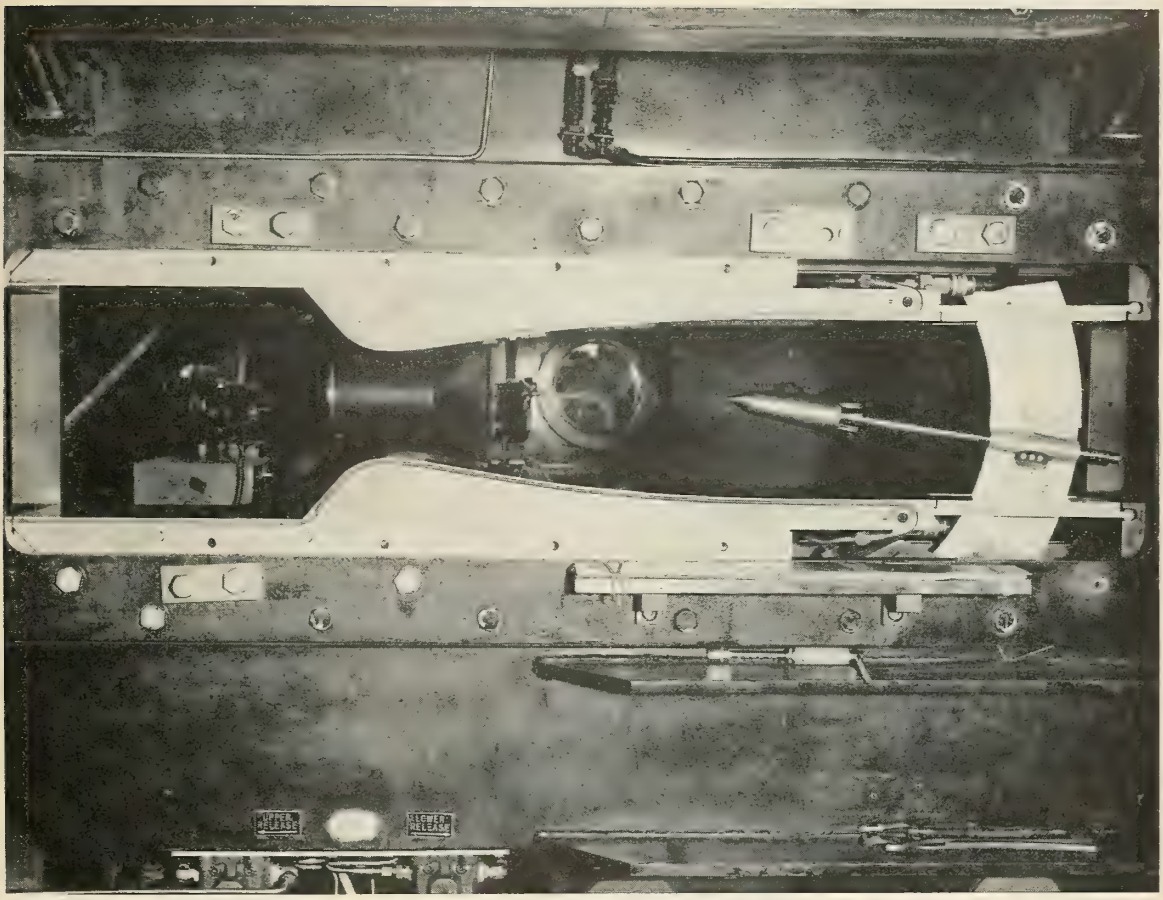
Some of the mathematical problems are so involved that Dr. Geissler pointed out the matter of programming the equations takes considerable time, although the electronic computers which deal with the programmed data can produce results quickly.

"One wonders," he observed, "if in the development of high speed computers there has been too much emphasis on speed rather than ease of programming. There are cases where much simpler procedures, even desk calculators, are competitive in view of their higher flexibility."

One of the current problems under investigation is the effect of wind upon large missiles. At the so-called "jet stream" level, 30,000 to 40,000 feet up, missiles encounter very high winds. Alabama's Polytechnic Institute is compiling a statistical evaluation of wind measurements for the Army Ordnance Agency as a part of this study.

One of the Laboratory's sections conducts studies of such factors as meteorological effects, wind, density, pressure, temperature variations, altitude, geographical locations, and the season of the year—which also has a bearing on missile performance.

Another section pre-calculates test flight trajectories with the assistance of the Navy's Dahlgren Computation Laboratory. Firing tables for the *Redstone* missile are being prepared by the Aberdeen Computation Lab. These tables will be employed by future Army missile men in the field such as the 217th Field Artillery Missile Battalion—the first unit organized to fire the *Redstone* —which is now in training at the Agency.

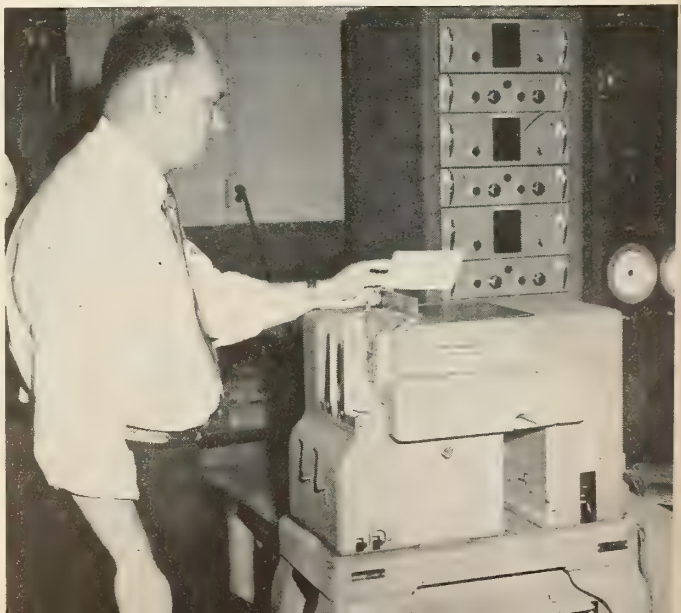


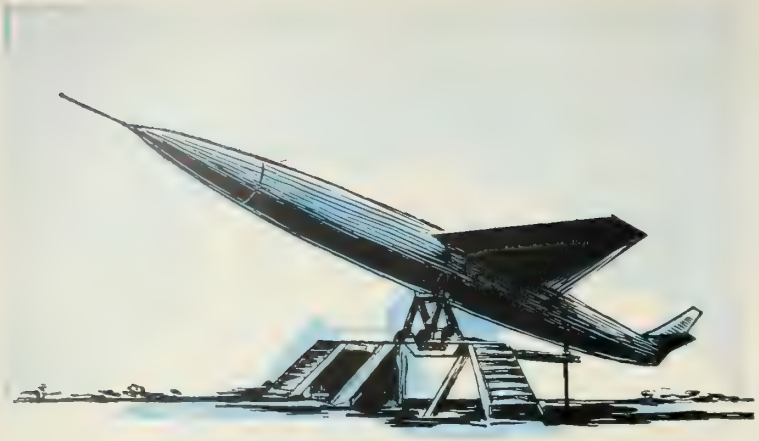
Missile model is pictured in position for aerodynamic testing in the Aeroballistics Laboratory wind tunnel chamber. High-pressure jet facilities are capable of testing within ranges from Mach 1.5 to Mach 4.5.



DR. ERNST GEISSLER, Director of the Army Ballistic Missile Agency's Aeroballistic Laboratory, is shown inspecting various models of missile warheads used in wind tunnel tests. This lab is assigned the mission of forcasting the behavior of Ballistic Missiles on the path of their flight from the firing base to the target.

Cards are automatically punched for later interpretation when information from wind tunnel tests is picked up by strain gage balances and pressure pickups and flashed to the electronic computing machines.





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Aerojet Expands Architect Engineer Services Division

Aerojet-General Corp. keeps expanding scope of its Architect-Engineer Services division.

Located at Covina, next door to the company's headquarters at Azusa, this division now has more than 600 architects and engineers. It provides such specialized services as static test instrumentation, flight-test range instrumentation, high-speed test tracks, rocket test stands and launching facilities, and complete propellant-handling systems.

One of its present major projects is the construction of facilities at Fort Churchill, Canada, for the launching of upper-air research vehicles during the International Geophysical Year.

Zip Fuel Sources For Ramjets

A U.S. Geological team is conducting a study of Southern California's unique dry lakes, seeking new reservoirs of boron, lithium and other non-metallic minerals. These elements have many uses, but high-energy fuel developments now add greatly to their value.

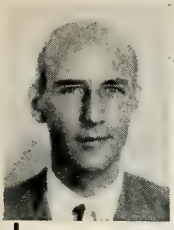
The so-called zip fuels for which these materials are required are just on the verge of coming into their own. Any problems that existed as regards their use in ramjet engines have been surmounted. At the same time, progress has been made with respect to turbojets.

For many years, the dry lakes and desert areas of Southern California have produced 95% of the world supply of borates. More than $25,000,000 worth of chemical products were mined from one of these dry lakes, Searles, in 1956. Hundreds of these lake beds dot the Mojave desert, but probably less than a score have ever been worked commercially. Only about six are being mined now.

Marquardt Named In Nuclear Propulsion

Marquardt Aircraft Co., producer of the ramjet engines for the Boeing *Bomarc* missile, has been named a prime contractor in the Air Force aircraft nuclear propulsion program.

President Roy Marquardt said the company is now engaged in studies directed at development of advanced nuclear propulsion systems.



Propulsion Notes

By Alfred J. Zaehringer

According to Bulganin, Soviet chemical production is to be stepped up. Pravda claims the new 1960 capacity is to be 91% over the 1955 mark. Among others, this reflects the expanding missile propulsion demands. Also, all satellite chemical industry will be integrated to form a huge Soviet centered chemical cartel.

The big guns in Soviet ballistic missiles are all of the lox-hydrocarbon type. Most widely used fuels are heavy gasolines, kerosenes, or fuel-oil grades. Apparently the difficulties associating the hot and heavy fuels have been solved indicating solution of combustion instabilities, hot spots, burnouts in large motors. All the big Red rocket motors operate at high pressures (viz., 500-1,000 psi).

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Russia is increasing its output of nitric acids and ammonia. However, nitric acid engines have only been used for smaller rockets (such as manned aircraft or AA). However, the USSR appears to be better sold on peroxide than the US in that they have at least one operational peroxide-propelled surface-to-air missile. Production of peroxide was recently doubled in Russia and also may be in for another increase under the new five-year plan.

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Increased amounts of ammonia will be going into ammonium nitrate for solid propellants. The Reds invested heavily in basic ammonium nitrate research and the payoff is coming in the form of increased use of these low cost materials for RATO, boosters, and long duration sustainers. The 1960 production goal of about 1 million metric tons of rubber and related synthetic resins implies trends toward increased use of new composite propellants.

•

The M-100 guided aircraft rocket has been drastically redesigned along with a rough halving of package size. The powerplant thus may be using ammonium perchlorate or some other high-energy solid in place of the old potassium perchlorate type propellant. Scale-up of solid propellant powerplants has been successful and operational units are operating at the ½-1 million lb-sec level. Further increases are anticipated. Most of USSR solid propellant development seems to be riding on composite propellants. Double-base propellants, however, are still being used for boosters, unguided aircraft rockets, infantry and artillery weapons. Big blank is new solid monopropellant work.

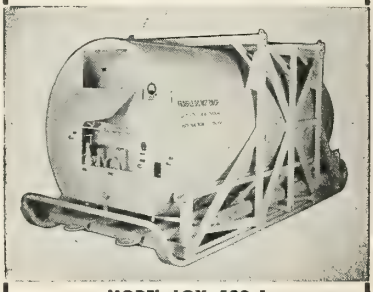
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Status of exotic fuel production is unknown. However, turbojets and ramjets are well trenched in the USSR aircraft and missile line. Most ramjet efforts are currently going into long-range, cruise-type, attack weapons. Work also appears to be in progress on nuclear propulsion (See m/r Oct., 1956). Present Russian thinking is quite conventional—the use of a working fluid (such as hydrogen or water) in conjunction with an atomic pile. Studies also have been reported on the direct utilization of high-speed nuclear particles, ion, and photon-type systems.

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Rocket powerplant development and production centers are located at Leningrad, Kasan, Kuibyschev, and Irkutssk. The entire system has its headquarters at ZIAM Institute in Moscow. Important test stands and ranges are at peenemünde, Kalinin, Uralskaje, Tomsk, and Kara-Kum.

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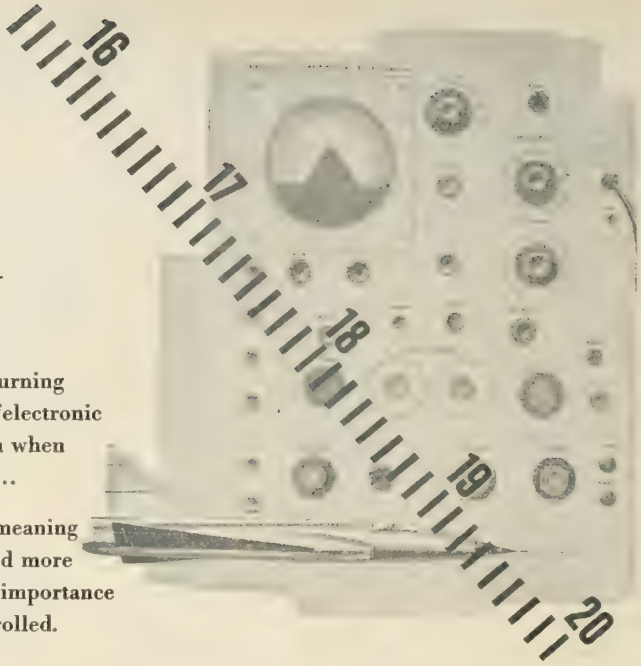
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How to get reliability



Got the automation jitters?...worried about turning complex manufacturing operations over to an "electronic brain"?...worried about what can happen when one component in the control system fails?...

Reliability takes on a new and different meaning as American industry becomes more and more automated. Here are a few thoughts on the importance of reliability and how it can be controlled.



All of us are going to have to pay more attention to "reliability."

We'll have to pay more attention to individual "devices" within a system.

We'll have to guard ourselves carefully when we design the entire system.

The industrial pendulum is swinging more and more toward automatic controls, servo-mechanisms, computers, and automatic "watchers." As it does, the reliability factor becomes more and more important. Let's see why. For example, you probably have three radios at home. If one fails because a soldered joint comes apart, your home life is probably not disrupted to any alarming degree. But... consider the automatically controlled steel mill. One soldered joint failing, unless all controls are installed in duplicate (which is expensive) could tie up the entire production process for valuable minutes, if the maintenance crew has second sight. For hours, if automatic trouble-indicating and locating systems are not installed (and these are expensive, too). Last, but not least, lend a thought to the dependence of guided missiles and man-made satellites upon the reliability of electronic circuits and components. So... let's start to examine "reliability." Let's begin by looking at this definition which is currently popular in the technical field:

The reliability of a particular component or system of components is the probability that it will do what it is supposed to do under operating conditions for a specified operating time.

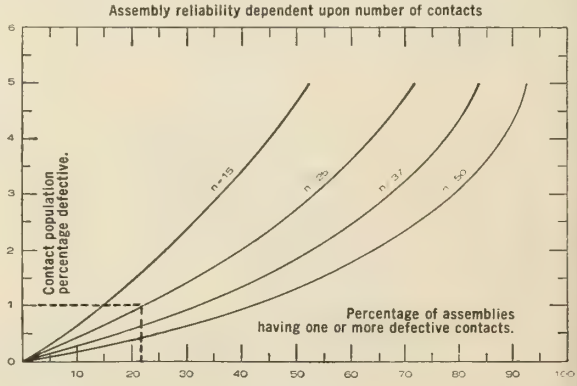
Now... this is a relatively well-accepted definition, and it offers the key to the problem of coping with failure control. Take the word "probability" in this definition. Let's discuss its implication.

Many of today's systems, simple or complex, are a chain of components. So picture a system as a chain with its successive links. In the field of statistics the over-all reliability of the chain is the mathematical product of the reliabilities of the individual links...

Overall Reliability, $R_o = r_1 \times r_2 \times r_3 \ldots r_n$

Now, let's consider a system made up of 100 different components, each of which has a reliability of 99%. In applying the formula, multiplication of .99 by itself 100 times gives an over-all reliability for the system of only 36.5%. Two out of three systems you have put together will probably fail!

Cannon becomes involved with this problem because our main business is making electric connectors. So, let's look at the following chart that covers contact reliabilities and reliability of the assembly in which they are mounted.





This chart illustrates the reliability of four connectors having 15, 25, 37 and 50 contacts respectively. As an example, assume that the contacts have a contact population of 1% defective (1 in 100 defective... this percentage is considered a fairly high standard in most fields). On the 15-contact assembly, we find from our chart that 14% of the connector assemblies would have one or more defective contacts! With 25 contacts, 22% would have one or more defective contacts. With 50 contacts, 41½%... is your hair starting to curl? Obviously, a 99% contact reliability standard for guided missile components is absolutely unacceptable. And, in between the simplest system and that of a guided missile, are hundreds of assemblies and systems whose reliability factors must be analyzed with utmost care.

But all is not lost! There's another side to the picture. With proper care, analysis, and control, our Cannon organization has actually achieved, in special "missile quality" contacts, a known level of only 2.85 x 10^{-3}% defective... only 1 part in 35,000! Naturally, we don't achieve that with all our contacts... but we do try to design and manufacture the utmost in reliability required for specific applications.

We have pictured this chart to show the direction we must all take, whether we're talking about connectors, other components, or systems. It boils down to two steps...

- The number (n) of components must be kept low ... *simplicity*.
- The level of component reliability must constantly be improved ... *hard work for all of us*.

Now... if we refer to our reliability definition on the previous page we note the phrase "do what it is supposed to do." So be sure *you* define these objectives for your component assembly, or system... failure to do so carefully can cause undue failure or the expenditure of unnecessary dollars for needless, excessively-reliable parts or design.

Further on in the same definition, we note the words "operating conditions." This brings up many new points for consideration. Here we are concerned with such things as temperature, pressure, humidity, corrosive atmosphere, stray electric and magnetic fields, low and high frequency noise, shock and vibration. Do your design standards need upgrading? Are your components designed and then tested to meet the operating conditions you specify... or are they designed to meet "average" conditions? Are you using adequate "safety factors"?

In a simple component, manufacturers have always looked for, recognized, and corrected faults when they occurred. We use component quality control to achieve and maintain Cannon's world famous product quality. But in complex systems such component quality control is not enough. Actually ...

Reliability control over the system is needed. It should be all-encompassing. When you get right down to it, *reliability* is the product of procedures, equipment, and people... in the design, manufacture, testing, control of quality, transportation, and use of products or systems.

Do you have a reliability control system?

Here are a few of the steps that are needed to get a reliability control system operating:

1. Determine Your Requirements. Specify the environment, operating time, performance limits, and the percent of reliability required. Allow an adequate safety factor keeping in mind the end use of the finished product.

2. Collect Reliability Data. Set up facilities for the continuous accumulation of data on component or system failures and their causes.

3. Establish quality control and test procedures which show high degree of correlation with end-use conditions.

4. Analyze. Determine if reliability requirements are being met. Establish the most important causes of failure by analyzing the data you collect.

5. Improve. Take action to eliminate the most important defects or causes of failure. Reduce the failure rate to the required level.

6. Maintain Continuous Vigilance. You have emphasized system design... you have used statistical analysis of failures... now exert continuous and critical control to be sure your "improvements" actually improve reliability. Examine new and unforeseen failure sources. Review and modify your requirements with changing conditions.

*

We at Cannon Electric are proud of our historical emphasis on quality and reliability. Since 1915 we have adhered to a design philosophy embracing the highest quality and reliability in each and every Cannon Plug for the specific application for which it is to be used. *If we can't design to that principle, we don't make it!* In manufacture, we are proud of our know-how in depth, proud of our fine quality control systems, proud of our personnel and proud of our reliability control group.

Whenever *you* have an electric connector reliability problem... in design, engineering, production, or prototype phases... we would appreciate the opportunity of discussing it with you.

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Approach to Solid Propellants

The key to the future growth of solid systems may well lie in processing techniques. We already have seen that we may be nearing the limits of chemical energy release in working systems.

In developing solid propellant systems cognizance must be taken of the present state of the art and projected developments. Due to present exigencies, we cannot be too specific about current systems. However, there is enough available data to give us a view of orders of magnitude.

Although homogeneous solids (viz., single and double base and colloidal propellants) released us from the shackles of the once standard gunpowder, they have somewhat restrained growth. Certain innate properties as high cost, low stability, and high sensitivity previously had given us a false view of the entire solid field. However, because of such factors as high burning rates and a large technological background, they are likely to remain in the picture for some time.

The advent of modern composites has, to a certain extent, released us from many of the shortcomings of homogeneous propellants. However, although we have tremendous possibilities with composites, our limiting factors are likely to rest on choice of oxidant. With large number of available fuel-binders, the composite field probably will be the most flexible in offering custom propellants.

The composite solid system is likely to be a stopgap field until we can synthesize a true, ideal solid monopropellant. Unfortunately, our knowledge of progress in the solid monopropellant field will be obscure for some time to come.

The gap between solid and liquid systems has been bridged by recent work, in hybrid systems. Performances greater than existing pure systems have been revealed at only slightly greater complexity.

Competing with Liquids

Designers now will be interested in a comparison of solid and liquid systems. Despite the fact that data may be restricted, a comparison is very favorable. Other factors such as handling, storage, reliability, etc. should be considered also.

Two Avenues of Approach

For the present and future, solid propellants have two avenues of approach in competing with liquids. For one, we can limit the field (by such factors as cost, applications, etc.). Or, we can take the unconventional approach. One technique to lower costs, for example, would be to design a system which yields a valuable by-product. That is, we would wind up with a propellant which can sell for less than that of its raw ingredient costs.

The general field of solid propellants has experienced a tremendous growth in a short period of time. Solids now compare very favorably with liquids. Hybrid systems now offer the possibility of bridging the gap between solids and liquids and make wider use of existing technology. Motor designers thus will have an extremely wide choice of high performance propellant systems. Designers of both active and inert systems should strive to maintain and better the present high degree of reliability in solid propellant systems.

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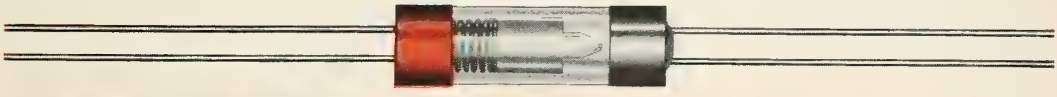
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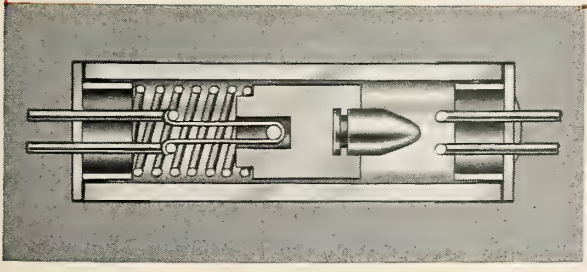
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Astrionics

By Henry P. Steier

Russian and other IGY delegates meeting in Barcelona last fall agreed to the resolution that both U.S. and U.S.S.R. satellite programs operate on the U.S. chosen 108 megacycle radio tracking frequency. At that time, Russian delegates announced they would "provide further data when ready" on their planned instrumentation load and satellite diameter.

Nothing further on Soviet astrionics has been heard officially from U.S.S.R. Oddly, latest news indicates the Soviets are maintaining their previously disclosed line in satellite thinking. It has come from Russian broadcasts beamed to Far Eastern countries. Members of the U.S. IGY Committee have been studying transcripts of the intercepted broadcasts with great interest—particularly in the inconsistencies with our program. Broadcasts are quoted as saying the U.S.S.R. satellites "ought to be" the size of ours but with a higher payload. Despite this rocket motor figures given are copied after ours.

If and when our "competing" satellites get up there first, the competition should not be felt in Russian scientific circles. Full data on what we find was promised the Russians through the International Council of Scientific Unions in Brussels. This ought to allay the fears of those who fear "pirating" of data stored in the U.S. satellites during each revolution.

As things stand now it's the high school kids and other potentially over-zealous amateur experimenters that worry U.S. satellite scientists about pirating. Since the stored information must be "dumped" by a signal from the ground at the right time, both deliberate and unintentional signals could wreak havoc with experiments. Naval Research Laboratories' John T. Mengel, who is the brains behind the satellite transmitter design, informs us the satellites will have their own "security system" designed to foil unauthorized dumping. He says it's not the utmost in security but is the best we can do with payload available.

Secret is "a couple of audio tones," Mengel says. Satellite astrionics will respond only to an rf signal modulated by this particular combination of tones. This is a hard one to beat. It's been very successful in airline Selcal, selective calling, systems. Specific combinations of audio tones enables airlines to call specific aircraft. Each plane responds only to a particular combination of tones to which it is tuned.

•

It's the little things that count. Among these in the Vanguard program are the gyroscopes being built by Minneapolis-Honeywell to control the vehicle's orientation to within 2.9 degrees. Outside that limit anything can happen. Observers who have toured Free Europe's laboratories say work there on producing super-accurate gyros is nil. What the Russians have in the way of inertial guidance is not known. Despite importance of propulsion, these "little things" could make or break the success of a scientific or military rocket vehicle design.

•

Another "little thing" is transistor technology. The Russians are now beginning to talk about transistor developments. These will be of first importance in our satellite astrionics gear. Russian talk of transistors is mainly in the computer field. They appear to have built very fast and large capacity data processing machines which they are beginning to transistorize. As with our IGY program, Russian satellite experiments would depend heavily on rapid and powerful computing machinery.

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The hydraulic system features drilled passages which eliminate the need for potentially troublesome plumbing. It includes reservoir, filters, temperature compensator, relief valve, check valve, and squib valve within a single housing.

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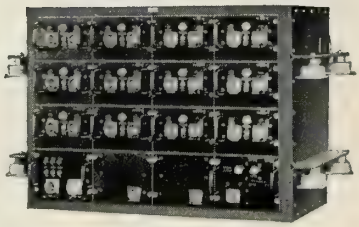


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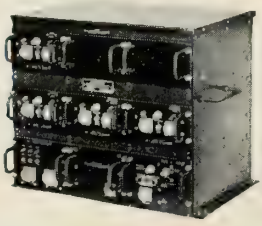
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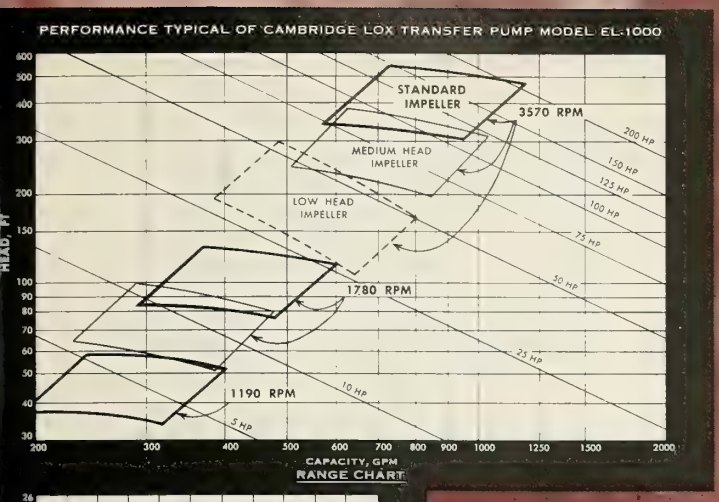
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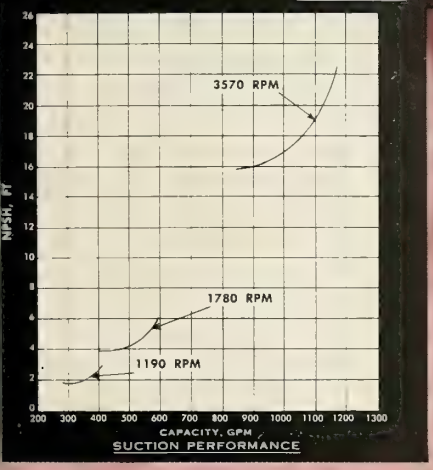
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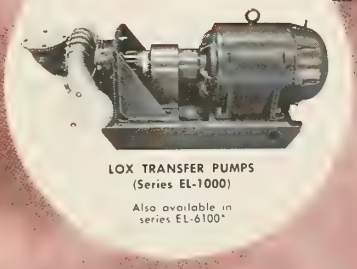


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Gear reduction: 135 to 1 in 2.25″ length
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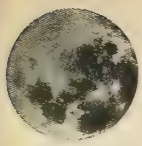
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Missile Miscellany

Where do you get your ideas? Try these: A rocket company with contracts and profits is making a missile in the shape of a sphere to operate in either air or outer space . . . At Hialeah last month, the Hibiscus Stakes, the favorite, Missile, lost to Honest Man . . . At a bar the other night, an AF officer declared that the Thor that goofed was "a production model" . . . same bar, same night this page heard odds quoted one-to-one the Vanguard would not be the first man-made vehicle to orbit the earth, or escape.

★ ★ ★

Has anyone ever used modern theory to explain why the silicate, Lintz basalt, spontaneously generates heat at a rate of 2.36×10^{-4} calories per hour per gram; why in free fall it won't accelerate at 980 centimeters per second^2? It's not radio-activity, for uranium is 1500 times as active as Lintz basalt, generates only 7.2×10^{-5} cal/hr/gm.

★ ★ ★

Lunch with this page's NACA structures engineer brought the observation that up to ICBM man had always been able to borrow from nature. Now reentry temperatures were known only at the sun's surface, the earth's center or in the stratosphere when meteors burn up. But what about meteors that make it down? What's the aero- or thermodynamics behind the myriads of spherical holes that pock their surface? And by mail, a missile valve and piping man wonders if anyone's tested the metal from Arizona's big meteor in missile applications.

★ ★ ★

A reporter member of ISAW, commenting on Pentagon policy of misleading the American public by letting them think the 3300-mile Jupiter-C missile is a Jupiter IRBM, suddenly asked: "Say, I wonder if Wilson's gone to Florida really to see the first full Jupiter fire?"

★ ★ ★

At home one night discussing the many and the varied with a working physicist, this page was asked: "Why not take the obsolescence out of education, start teaching the thinking of Field Relativity Theory in grade school when it's new and logical, instead of later when it's contradictory and disturbing; let it grow with the young, inquiring mind and perhaps, like that mind, expand?"

★ ★ ★

Then, in New York at the recent Institute of Aeronautical Sciences meeting, an Admiral unofficially insisted that the missile-equipped Navy of the future will have to go 100% underwater, and that once it does, its missile ability will top Army's and AF's.

★ ★ ★

With cracks like "Snark-infested waters" and the "Thor Myth" going about, it's no surprise a recent failure of another missile to make it farther than the adjacent launching pad leads to the AF quip: "Have you heard about Army's latest Inter-Pad Ballistic Missile?" . . . with the progress being made in jellied propellants, why can't later models of the Polaris be "liquid" after all . . . AF now forbids its civilian scientists to voice impressions of Soviet scientists on the grounds of military security "in the international political field" . . . from a manufacturer of high temperature materials like brake linings, an offer of a laminated reentry nose cone that will take 6000 degree boundary layer temperatures for 18-20 seconds . . . and just in case you thought the reaction motor was something new, Heron's steam driven Aeolipile amused the Greeks in 300 B.C. . . .



★ ★ ★



INDUSTRY SPOTLIGHT

By Joseph S. Murphy

Civil Application of Missile Know-how

Some missile principles and techniques are being applied to consumer industries with surprising success. The fact that missiles are of a highly technical nature and that the military have top priority in their research, are not valid reasons for holding up consumer industrial progress in any way. Rather, research men are "squeezing" every drop of helpful information possible from their pool of guided missile information and data.

Guided missile work has already proven useful in these consumer fields in the design of propulsion systems, airborne navigational aids, and machine tools. Research on upper air phenomena, miniaturized electronics and precise automatic computers are of more recent vintage.

Future aircraft fire control systems are in advanced stages and are of a classified nature. They include the design and development of systems to meet the tactical and strategic requirements of new bombers, fighter-bombers, and interceptor aircraft.

Other improvements for the future are new techniques in integrating flight control computer and radar functions of fire control systems that will make present-day computing gunsights obsolete.

Impact on Industry

Needless to say, fire control systems, missiles, and their components have had a tremendous impact on industry as a whole. They have undoubtedly had a great deal to do with the estimate of a leading firm that today one out of every eight workers in the company is a technical employe. In 1943 the ratio was one out of every one hundred.

One of the chief industries to be influenced by this surge in technical employment is the electronics field. This is especially true of military aircraft fire control systems where more tubes are being required.

Already the U.S. Air Force for 1957 has allotted 17.3% of its aircraft procurement budget for electronics. In 1952 less than 10% was spent. Airborne radar requirements, for example, have increased from $11.4 million in fiscal 1955 to $35.6 million in 1957. Electronic countermeasure equipment requirements call for $195.5 million in fiscal 1957.

Within these figures lie jobs—many jobs—technical as well as semi-technical and even non-technical. More jobs, of course, mean less unemployment, more buying power.

Right now the guided missile and weapons field is literally begging for engineers and technically trained personnel for careers in aerodynamics, electronics, propulsion, optics. Hundreds of ads appear in magazines and newspapers daily, seeking engineers and scientists with creative skills in aircraft and missile systems.

The job of developing missiles and weapons systems has been dropped in the lap of industry and, in come cases, almost abruptly. At no time in history, however, has there been closer cooperation between industry and the Armed Forces of our Government for the development of these defense weapons. Never has industry held such crucial and great responsibility. Industry's performance in utilizing its facilities and talents to the utmost is the key factor in the keen competition shown and is largely responsible for the progress we have made to date.

In the past there were grumblings about industry being shouldered with responsibility but hampered by (1) ignorance of long-range Armed Forces needs (2) by the state of the development art and (3) by inability to get a decision out of a "complex uniformed bureaucracy." In many instances these grumblings were justified. This should not be the case now. Industry must now "carry the ball"—all the way.

Fortunately, the discoveries coming from today and tomorrow's fire control and missile developments by American industry have not been for war alone. Many great possibilities exist for the future and a world of peace.

Today's automatic pilots and remote control devices in missiles can be put to work to control the flight of aircraft when human ability is not adequate because of high speeds or atmospheric conditions.

Automatic instruments inside a missile can steer an explosive warhead directly to a ground target. These systems can be geared to a compass for direction, to an altimeter for height of climb, to a propeller that acts as a odometer for distance, to a telescope that navigates by watching the stars, or even to a television set that looks for a spot on the ground.

Why can't similar systems be devised to land high-speed aircraft on the runway in any weather or visibility? In fact, why can't such a robot craft be used to deliver important documents or much-needed serums or drugs in emergencies to distant places in short time, regardless of weather—a sort of "missile-mail" service?

New and greatly improved automatic computers are beginning to run offices and factories.

Because of the need for sending technical information to the ground from a test missile, telemetering has appeared. This is nothing more than measuring conditions on a vehicle in flight and radioing the information back. The telemetering principle is already being followed in earthbound machines. Information is sent automatically from one part of a machine to another, used (again automatically) to direct the whole machine's operation. This, the feed-back mechanism, is leading us toward "automation."

Such a missile guidance system would have to be modified to land a plane. It could be redesigned to control the flaps at a certain time, level out, and stop engines. Information obtained by radar could be fed into a computer which could calculate exactly when and how much to begin braking.

It is not inconceivable that directional forward firing rockets, automatically controlled by instrumentation originally developed for missiles, could gradually bring a plane about to crash to almost zero velocity before impact.

These are but a few of the peacetime possibilities that exist for missiles and rockets in the future.



Industry Highlights

By Fred S. Hunter

A well-known household remedy, milk of magnesia, is being used successfully by North American Aviation as an inexpensive thread lube. Before milk of magnesia was tried, North American had been experiencing a high breakage rate on bolts and clamps on stress relieving and welding fixtures placed in ovens for post-forming operations. Application and removal of milk of magnesia is easy, says Ed Cane, conservation committeeman in the missile detail department at Downey. It is daubed on threads with a brush; after removal from the oven it is in powder form and is easily dusted off.

Lockheed's Missile System division has installed a new Baldwin 440,000-pound hydraulic universal testing machine in its engineering laboratory for its structures test group and it would, of course, be dubbed *Big Bertha*. It is able to test components up to 65 inches wide, 11 feet long (in tension) and 12 feet long (in compression) in its vice-like arms. The $36,000 machine's four load ranges read to an accuracy of plus or minus ½%.

At this writing, all Boeing has announced is that it has options on land in the San Ramon Valley in California for possible construction of a *Bomarc* production plant and on the Ford Motor Co. plant at Richmond, Calif. But word is being freely passed around that the joint plants of the Seattle manufacturer and the Air Forces will involve a total investment of $100,000,000 for plant, equipment, etc. Seems like a pretty large sum even though *Bomarc* is a pretty large program.

A U.S. Geological team is conducting a study of Southern California's unique dry lakes, seeking new reservoirs of boron, lithium and other non-metallic minerals. These elements have many uses, but high-energy fuel developments now add greatly to their value. For many years, the dry lakes and desert areas of Southern California have produced 95% of the world supply of borates. More than $25,000,000 worth of chemical products were mined from one of these dry lakes, Searles, in 1956. Hundreds of these lake beds dot the Mojave desert, but probably less than a score have ever been worked commercially. Only about six are being mined now.

Rocketdyne has installed a new emergency telephone system that makes good sense. Employes at the main plant in Canoga Park dial 333 and those at the Santa Susana test facility dial 555. This puts 'em through to the central control operator. A new-type of number disk is being placed on all Rocketdyne telephones. In addition to telephone and extension number usually found on these disks, the correct emergency number will be listed and the telephone location, such as Room 27 or Column 00.

Raytheon's new laboratory opposite the Santa Barbara airport for the design of electronic and infrared equipment for the government is scheduled to be ready for occupancy by mid-summer . . . More than 40 of Aerojet-General's Aerobee sounding rockets will be launched during the International Geophysical Year program at the launching facility installed at Fort Churchill, Manitoba . . . North American's transplanted Californians were treated (?) to a brand new type of weather at Rocketdyne's Neosho, Mo. plant when 1.48 inches of rain, snow and sleet broke power lines, knocked out telephones and completely stopped work at the plant . . . Art L. Hubbard, recently named to head the newly established systems test facility department of Lockheed's Missile Systems Division, was the first employe selected by the division to attend UCLA's two-year engineering executive program begun last year.

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Poly-Scientific is synonymous with versatility, precision, and performance. Every slip ring, commutator and brush assembly made by Poly-Scientific is the ultimate in quality.

The use of epoxy resins allows greater miniaturization without sacrifice of strength. Our perfected techniques permit the use of any of the noble metals and alloys, making possible the selection of the optimum material with the proper hardness for each specific application.

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miniaturized slip ring assemblies
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commutators
to fit any requirement



A real achievement in sub-miniaturization: thirty-two 0.140" diameter rings in less than one inch of length, with no sacrifice of electrical or mechanical characteristics! Rugged and accurate stainless steel flange and center rod insure perfect alignment. Solid coin gold rings of 140 Brinnel hardness are finished to a high polish. Also note color coded teflon insulated leads.

This extremely accurate commutator, used to generate a critical impulsing sequence, is fabricated with coin gold segments common to the end contact and P-30 epoxy resin, the combination of which guarantees uniform wear and long life.



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In air-foil sections, strength, accuracy and smoothness are of primary importance. These characteristics, plus a minimum of machining, are offered by this Antioch Process missile fin casting. The alloy: A-356. Tolerances of ±.010″ in thickness and .020″ T.I.R. on flatness are held in production. Surface finish, as cast, is better than 125RMS. Test bars machined from heavy hub section have minimum ultimate strength of 36,000 psi and elongation of 11%.

Morris Bean & Company specializes in casting parts for wave guide, fluid flow, and aircraft application to demanding standards and in volume production.

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Yellow Springs11, Ohio

a cast rocket fin?



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New Missile Contracts Announced

Commerce Department's synopsis of new Defense contracts at presstime listed four new awards to missile and rocket firms.

Douglas Aircraft Co.-Santa Monica received three contracts totaling $2,340,083 covering facilities for *Thor* WS-315A medium range ballistic missile production.

Thiokol Chemical Corp. of Elkton, Md. won a $1,520,527 award to produce M-58 rocket engines for *Falcon* missiles and Phillips Petroleum Co. of McGregor, Tex. a $442,000 contract for JATO development and production facilities.

Hycon Manufacturing Co. was awarded a $404,000 contract to produce missile test sets.

Interstate Gets $½ Million Order

Interstate Engineering Corp. has received an order valued at approximately $500,000 from Consolidated Western Steel Corp. for production of rocket launcher cylinders for the *Nike-Hercules.*

The company also produced similar cylinders for the original *Nike.*

Sperry Sets Up Air, Surface Armament Divisions

Sperry Gyroscope Co., Div. of Sperry Rand Corp. has established two new divisions—an Air Armament Division and Surface Armament Division.

The Surface Armament Div., under Myron D. Lockwood, has been assigned responsibility for original development, design, manufacture and sales of ground, shipboard and submarine armament products.

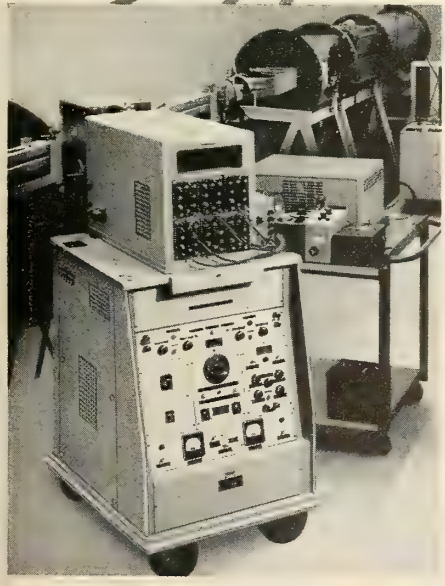
The Air Armament Div. headed by Samuel Agabian, will have similar responsibilities in the fields of air armament, missile guidance systems and navigational equipment.

Cornell Developing New Test Facility

A new hypersonic test facility capable of testing aircraft and missile designs at simulated speeds of 10,000 mph and 9,000°F temperatures is being developed by Cornell Aeronautical Laboratory, Inc.

Feature of the new installation will be its test endurance. It is said to be capable of maintaining the high-velocity, high temperature airflows for peri-

tomorrow's hypersonic speeds are being measured TODAY...



with the HATHAWAY SC-16B CATHODE RAY RECORDING OSCILLOGRAPH

If your tests demand accurate, time-resolved records of realistic high-speed phenomena experienced during test runs of millisecond duration, the SC-16B is absolutely essential.

Problems beyond the galvanometer oscillograph range, such as Mach 20 conditions, 20,000°K temperatures, dissociation, thermal radiation and mass ablation, are being recorded with this mobile instrument.

The dependable, self-contained SC-16B is specifically designed to meet the many requirements of today's research. It records up to 6000 in/sec within 16 instantly selected chart speeds and has a frequency range from DC to 200,000 cps.

Detailed specifications will help show you how important the SC-16B can be in your application.

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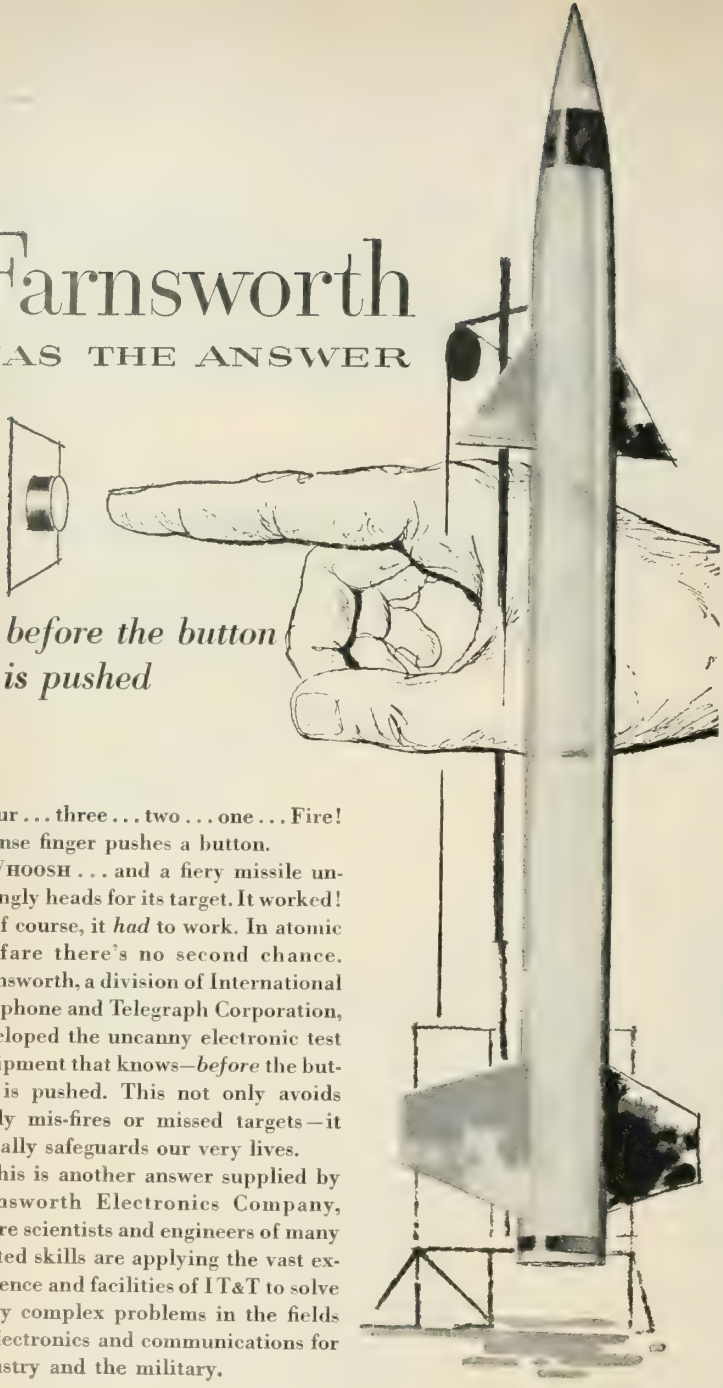
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Farnsworth

HAS THE ANSWER



...before the button is pushed

Four... three... two... one... Fire! a tense finger pushes a button.

WHOOSH... and a fiery missile unerringly heads for its target. It worked!

Of course, it *had* to work. In atomic warfare there's no second chance. Farnsworth, a division of International Telephone and Telegraph Corporation, developed the uncanny electronic test equipment that knows—*before* the button is pushed. This not only avoids costly mis-fires or missed targets—it actually safeguards our very lives.

This is another answer supplied by Farnsworth Electronics Company, where scientists and engineers of many related skills are applying the vast experience and facilities of IT&T to solve many complex problems in the fields of electronics and communications for industry and the military.

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CAREER OPPORTUNITIES: There are important new openings on our professional staff for graduate engineers and scientists. Write for complete information. Confidential.

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FARNSWORTH ELECTRONICS COMPANY, Fort Wayne 1, Indiana
A DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

ods up to 15 seconds, far longer than before possible.

The $2 million facility is an Air Force funded project that uses a new wave superheater described as a unique arrangement of tubes capable of producing a continuous flow of high-speed hot air.

Lockheed Missile Division Forms Two New Units

Two new weapons system organizational units have been formed under Lockheed Aircraft Corp.'s Missile Systems Division in its new Palo Alto and Sunnyvale, Calif. facilities.

Heads of the new groups will be John H. Carter, MSD associate research director and Stanley W. Burriss, former division engineer in charge of flight test activities. New groups will have the responsibility of developing and interpreting MSD obligations under specific contracts as they are assigned.

NAA Consolidates Purchasing Office of Rocketdyne Division

Purchasing activities of North American Aviation's Rocketdyne Division have been consolidated under one roof with the recent shift of 600 employes into a new materials building in Canoga Park, Calif.

Division purchasing, which involves a $60 million annual volume, supports local production of the Rocketdyne Division and involves more than 3,000 suppliers in 34 states.

NAA Nets $9.8 Million For First Quarter

North American Aviation, Inc. reports a net income of $9,898,999 for its first quarter ended December 31, a $2.7 million increase over the same period in 1955. Sales and income for the period amounted to $330,526,940 compared to $195,935,978 a year ago.

NAA's net represented $1.23 as share against $0.89 in the first quarter of 1955. Federal income taxes were estimated at $10,722,000 for the three months based on preliminary figures.

Advances in Digital Telemetry Reported

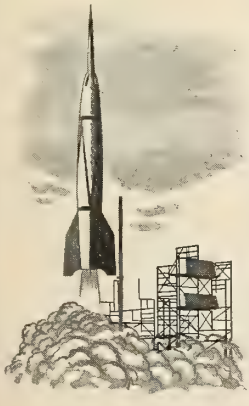
A new system of handling information in direct digital form is opening a serious bottleneck in telemetry and said to be saving up to six months time



Being interviewed is Joseph Sullivan, Manager of the Silver Battery Division

"They're small in size, but they're for large missiles"

At the Exide Laboratories:—



Reporter: Do large missiles usually need a higher capacity battery?

Sullivan: Yes, because there are generally heavier loads to be energized.

Reporter: How do you get high capacity into such small sizes?

Sullivan: Well, we do it in this case with silver zinc rechargeable batteries.

Reporter: What are the advantages of silver zinc?

Sullivan: We find it combines the greatest reliability and output per unit of weight and volume of any type now in use.

Reporter: In what range of sizes do you make silver zinc missile batteries?

Sullivan: You're looking at four sizes rated at 5, 20, 40 and 60 ampere hours. We are also prepared to build batteries of any size from ½ to 150 ampere hours—or greater.

Reporter: You say these batteries are rechargeable. Do you also make so-called one-shot or primary batteries?

Sullivan: Yes. And the silver zinc primary batteries built by The Electric Storage Battery Company have hermetically sealed electrolyte systems that insure long shelf life.

Reporter: Then you offer a stock line of missile batteries?

Sullivan: We do. And in addition, we have the engineering staff and manufacturing facilities to design and build batteries to meet an unlimited variety of different requirements.

Note to missile manufacturers. When you buy batteries, be sure to get all the advantages available in Exide Batteries. For complete technical information, write Missiles Application Department of the Exide Industrial Division, The Electric Storage Battery Company, Phila. 2, Pa.

THE ELECTRIC STORAGE BATTERY COMPANY **Exide**®

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NEW

Trans-Sonics*

"TAPE-ON" SURFACE TEMPERATURE RESISTORS

for Temperature Telemetering

- NO THICKER THAN A PIECE OF TAPE
- OUTPUT UP TO 5 VOLTS WITHOUT AMPLIFICATION
- AVAILABLE IN VARIOUS RANGES FROM −300° to +400°F.
- RESISTANCE CHANGE OF 100 OHMS OVER SPECIFIED RANGE
- NO HOLES TO DRILL — QUICK AND EASY "TAPE-ON" INSTALLATION

Trans-Sonics Type 1371 "Tape-on" Surface Temperature Resistors are precision resistance thermometers with a platinum resistance winding as the sensing element. These resistors which are no thicker than a piece of tape may be applied to *any surface* whose temperatures are to be measured. In a commutation circuit, they modulate standard telemetering transmitters without amplification. The new Type 1371 "Tape-on" Surface Temperature Resistors may be added to an installation using other Trans-Sonics temperature transducers without any further circuit modification. Each resistor is furnished with 6" long fibreglas-covered constantan leads. Write for Bulletin 1371 to Trans-Sonics, Inc., Dept. 9.

*Reg. Trademark

SPECIFICATIONS

SIZE: ¼" x 5/16"

Accuracy: ±2% of full scale range

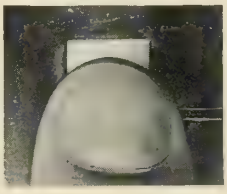
Precision: ±0.5% of full scale range

Maximum Continuous Current: 20 ma rms (averaged over 1 second)

Environmental Operation Conditions
Vibration: 1" double amplitude, 0 to 22 cps ± 25g, 22 to 2000 cps

Shock: 100g in any direction, per paragraph 4.15.1 of MIL-E-5272A (10 milliseconds shock)

INSTANT INSTALLATION



As easy to apply as a thumb print.

For Transducers, See Trans-Sonics

Trans-Sonics, Inc.

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Circle No. 41 on Subscriber Service Card.

in the analysis of rocket and missile flight data.

A system developed by Radiation, Inc. for digital data computing receives information in direct digital form at a speed of 24,000 samples per second with an accuracy of one part in 256.

Two of the systems have been built and are in use by Wright Patterson AFB and Convair. Other systems are under development for AC Sparkplug, AVCO, Holloman ADC, Kirkland AFB and project *Vanguard*.

R-W Center Takes Shape

Ramo-Wooldridge Corp. has completed the first unit of a nine-building research and development center being built on a 41-acre site south of Los Angeles International Airport.

First building is assigned to the company's control system division, electronic instrumentation division, and two laboratories—one for aeronautical research and the other for electronics research.

Office and laboratory space in the first unit will accommodate about 500.

Douglas Investing $3 Million In New *Thor* Facilities

Douglas Aircraft Co. plans to spend up to $3 million over and above the $1,305,500 in funds supplied by the Air Force for construction of a guided missile facility in the Sacramento area this year.

F. W. Conant, senior vice president, said more than $2 million in contracts already have been let for land clearance at the 1,700 acre site, construction of roads, missile test stands, assembly and modification hangars.

Outstanding contracts also provide for a cafeteria, fire and plant protection building and control building.

The new Douglas facility will be used initially for development and test work on the Air Force's *Thor* IRBM.

Lockheed Talks Terms On Four New Missile Deals

Lockheed Missile Systems Division is negotiating four additional contracts, according to general manager L. Eugene Root. In a year-end review, Root said the division started 1956 with a dozen major contracts and a number of minor ones and added two very important new jobs and eight minor ones during the year.

Lockheed recently was named major contractor in the Navy's new *Polaris* fleet ballistic missile program;

missile division sales are running at about $60 million annually compared to $24 million a year ago and backlog has doubled in the last six months.

Missile Spending Reaches $1.5 Billion Annual Rate

Total Defense spending by Army, Navy and Air Force for the first four months of fiscal 1957 reached $506,249,000 for an annual rate exceeding $1.5 billion. The unexpended balance as of October 30 stood at $3,828,245,000 with individual services reporting these accumulated spending figures for the four months:

Army	$116,977,000
Navy	67,851,000
USAF	321,421,000

New missile obligations for the period totaled $699,217,000 with this breakdown by service: Army—$86,289,000; Navy $134,029,000; and USAF—$478,899,000. Unobligated balance on October 30 for the three services was $1.98 billion.

RMI Income, Backlog Increase Sharply in '56

Preliminary 1956 year-end figures for Reaction Motors, Inc. show sales in excess of $15,500,000, an increase of nearly 50% over 1955. Company officials expect the final 1956 report to show a substantially higher net profit after taxes of at least $330,000.

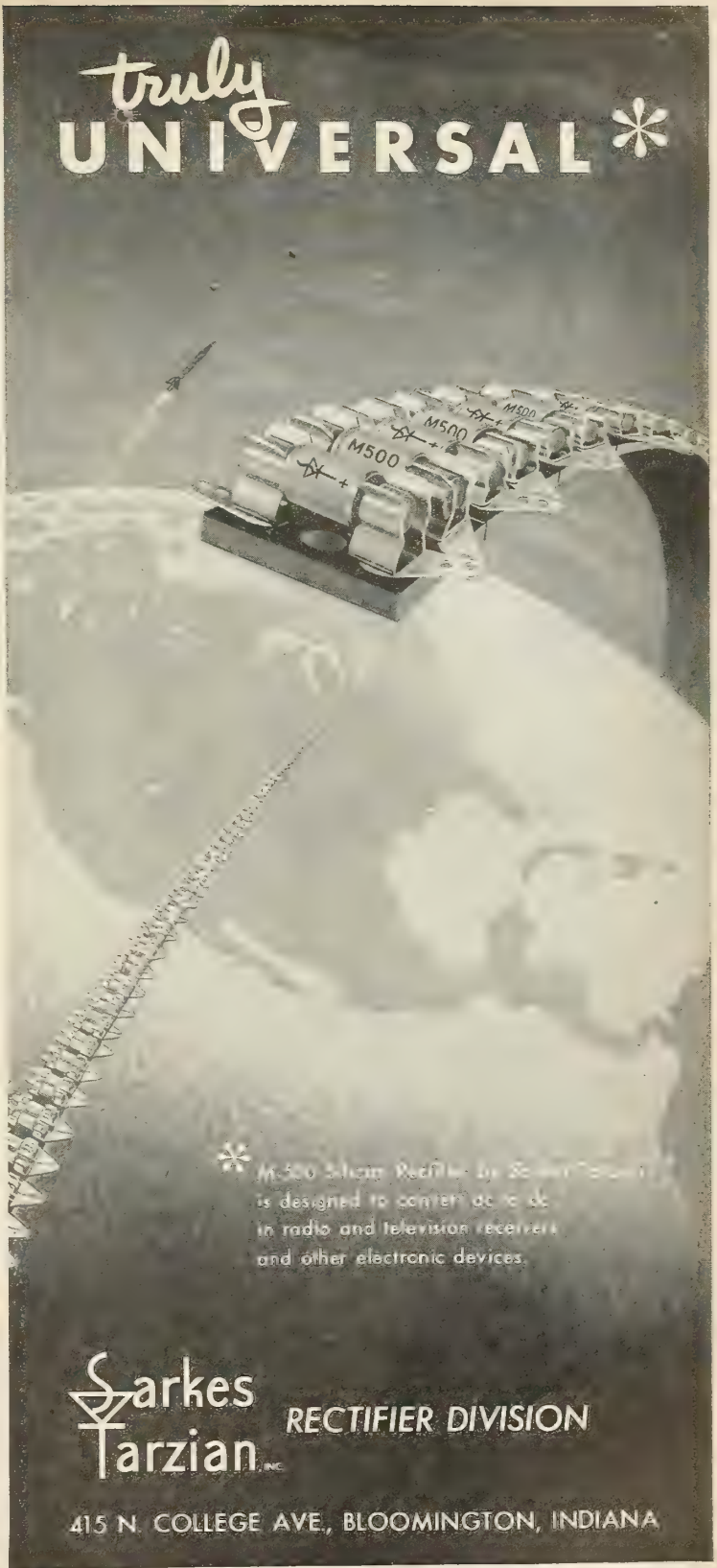
RMI backlog on December 31 stood at $22 million, up about 150% over the same time in 1955. Employment was 1,350 compared to 669 at the beginning of 1956.

AF Awards 3 Contracts For Ballistic Missiles

Air Force has negotiated cost-plus fixed fee contracts totaling nearly $600 million with Douglas, Convair and Martin—prime contractors in the *Thor, Atlas* and *Titan* ballistic missile programs respectively.

Largest of the three, amounting to $358,000,000 went to Martin for design, fabrication and testing of the *Titan*. Award to Convair for similar activity on the *Atlas* was valued at $145,000,000. Douglas' contract for the *Thor* totaled $67,500,000.

Dollar values of the contracts, however, were labeled "rough estimates," not to be used as an index of the size of the three projects. The Martin contract, for example, covers a substantially longer period than that awarded Convair or Douglas.

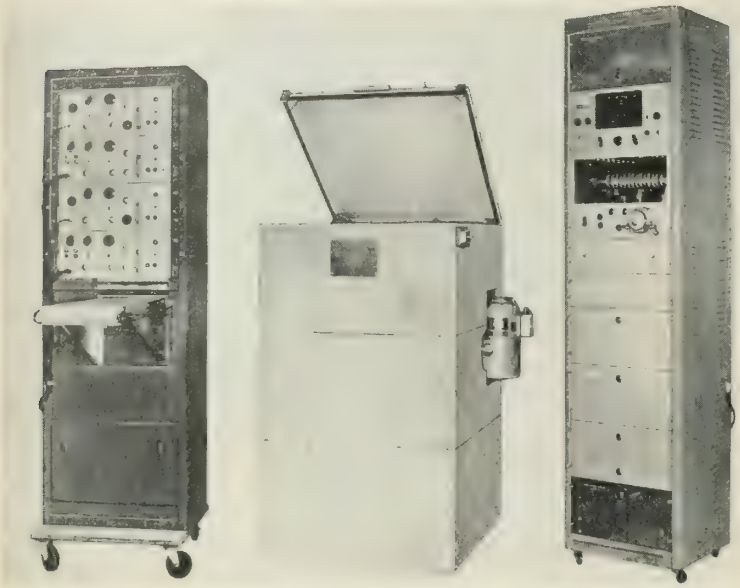


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Circle No. 40 on Subscriber Service Card.

NEW MISSILE PRODUCTS

ROCKET FLIGHT SIMULATOR



A simulator for acceleration-sensitive devices used in rockets and missiles permits testing for acceleration and deceleration effects. A vector seeking specimen mount is used which eliminates nearly all undesirable side accelerations. An acoustic specimen cavity and special microphone permits audio data sensing of hermetically sealed units.

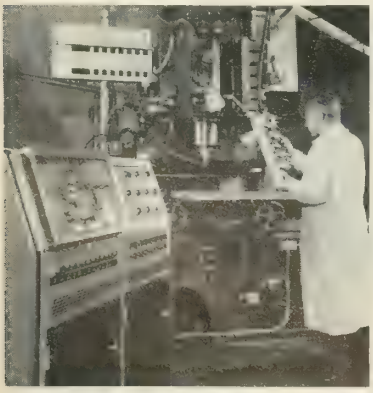
Two energy storing flywheels are used which can accelerate a device from 2 to 125 g in 200 milliseconds. Minimum braking time is 100 milliseconds. Maximum flight time is 55 seconds. A program unit controls acceleration-deceleration cycling through adjustable cam operated switches which control magnetic clutches and brakes. The Magnavox Co.

Circle No. 205 on Subscriber Service Card.

MACHINE CONTROL SYSTEM

North American Aviation's Autonetics Division has developed Numill, a tape control system designed big-machine automation to small lot and single part production of aircraft and missile tools and parts.

The system is adaptable to lathes, boring mills, contour mills and grinders



and permits finished tools or parts to be produced without use of blueprints. Sole guidance for machine operation is provided by instructions recorded by a standard electronic brain on magnetic tape and continuously monitored by automatic electronic gauges.

Basically, its operation hinges on the transfer of recorded instructions from the tape into electrical signals to direct the movement of the machine. An instruction panel specifies the materials and tools to be used.

Within a few years, North American officials predict, control systems like Numill will be in widescale use in by firms engaged in small lot production. Further, their use will provide the competitive advantages of improved parts uniformity, reduced costs and greatly shortened lead times.

North American Aviation, Inc., Autonetics Div., International Airport, Los Angeles 45, Calif.

Circle No. 207 on Subscriber Service Card

TEMPERATURE PROBE

A temperature probe for missiles and aircraft features very high recovery and negligible radiation and conduction errors for operation to temperatures of 1000° and 2800°F. For either boom or strut mounting, the T-1305 aircraft total temperature probe can be obtained with a choice of resistance or thermocouple elements. Resistance elements of wire wound type go to 1000°F and thermocouple types to 2800°F.

The units use the double stagnation principle and are said to have rapid response to temperature changes and complete insensitivity to 20 degree angle of attack. Aero Research Co.

Circle No. 204 on Subscriber Service Card.

PRESSURE TRANSMITTER



New Synchrotel pressure transmitters designed for use in high performance aircraft and guided missiles weigh about one pound, about one-third that of previous models, according to the manufacturer.

The Synchrotel transmitter are used for transducing pressure values as electrical signals. They are used with air and navigation data computers as well as flight and engine control systems where accurate measurement of pressure functions is a must and where space and weight are at a premium. Kollsman Instrument Corp.

Circle No. 208 on Subscriber Service Card

KATO
400 CYCLE
MOTOR
GENERATOR SETS
FOR AIRCRAFT TESTING EQUIPMENT



CHANGE 60 CYCLE A. C. TO 400 CYCLES

Now Up to 250 KW
FOUR SPEEDS—1200, 1714, 2000, 3430 RPM

KATO MOTOR GENERATOR SETS are now available in frequencies, speeds and sizes to meet most every specialized use . . . Testing . . . Lighting . . . Operating high cycle tools, smaller lightweight 400 CPS motors, transfers, filters, condensers, chokes and other electronic equipment. Finest quality materials and workmanship.

Variable or fixed frequencies ranging from 25 to 1200 cycles. 60-Cycle line, up to 500 KVA.

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Circle No. 21 on Subscriber Service Card.

GYRO ROTOR ALLOY

New high-strength, high density alloy introduced by P. R. Mallory & Co. for use in gyro rotors is said to withstand rotor speeds about 25% higher than allowable with other materials.

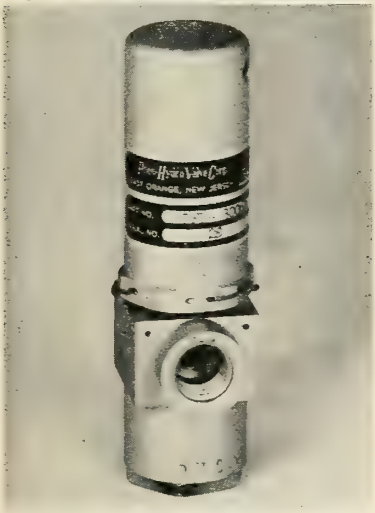
A sintered alloy of tungsten, nickel, copper and other elements, Mallory 1000 Gyromet has a density of 16.70-17.05 grams per cubic centimeter. Proportional elastic limit is 62,000 psi and endurance limit 55,000 psi.

According to its producer, the new alloy has considerably higher stability and strength than previously obtainable, an indication of its potential use in inertial guidance systems where exceptional precision and uniformity are in demand. P. R. Mallory & Co.

Circle No. 212 on Subscriber Service Card

PRESSURE REDUCER

New series of lightweight pressure reducers designed to meet Spec. MIL-R-8572 range in weight from 0.4 to 0.6 lbs. and are intended for 3,000 psi aircraft and missile pneumatic systems. Units are available for ¼-in. and ⅜-in. tube sizes with larger models supplied on request.



Valve design includes built-in relief provisions, but reducer is available without this feature for special pneumatic or hydraulic system installations. Unit is balanced for straight-line regulation, leak-tight shut-off and small initial pressure drop. Operating temperature range is from —65°F to 225°F. Pneu-Hydro Valve Corp.

Circle No. 210 on Subscriber Service Card

TEMPERATURE SENSING RESISTORS

A new line of "Tape-On" surface temperature resistors that can be applied to any surface with a small piece of Mylar tape have been announced. Designed for temperature telemetering, the sensing elements have an output up to 5 volts and can be used directly in a commutation circuit to modulate standard telemetering transmitters.

Resistance change over the temperature range is 100 ohms. The resistors are available in various ranges from —300°F to +400°F. They have two 6" long fibreglass covered constantan leads.

Size is ¼" x 5/16". Accuracy is rated at ±2% of full scale range. Precision is ±0.5% of full scale range. Maximum continuous current is 20 ma rms (averaged over 1 second). Trans-Sonics, Inc.

Circle No. 216 on Subscriber Service Card

SEALED SWITCHES

New hermetically-sealed, potted switches for aircraft and missile use feature a threaded actuator plunger guide for versatility of mounting. This arrangement permits location of switch actuator button flush with mounting board or at any extended distance up to ⅞ in.

Model No. 9129, when mounted on actuator, has ⅛ in. overtravel with equal pretravel along the plunger. Tests by manufacturer indicate units conform to MIL Spec. 50-g shock limits.

Actuator button is compounded from special elastomers said to flex satisfactorily at —90°F and at 285°F. Switch is bonded to switchover and is rated to withstand 100 psi pressure differential inside to outside without rupture or leakage. Literature available. Haydon Switch, Inc.

Circle No. 211 on Subscriber Service Card

METAL LAMINATES

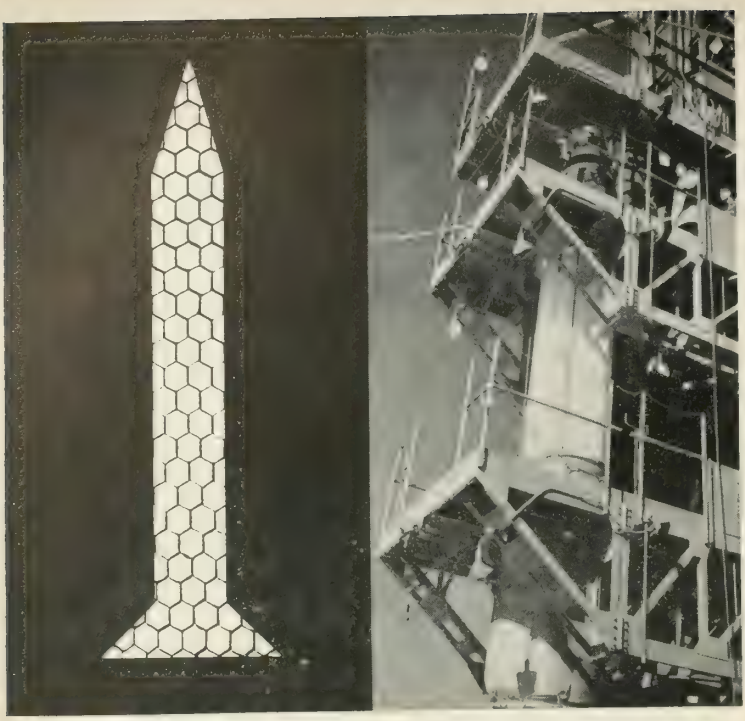
A new series of metal laminates employing a true metallurgical bond in combinations of two or three metals have been unveiled by Bridgeport Brass Co. Combinations include stainless and mild steels, Monel, copper, brass and titanium plus some precious metals bonded to form laminates or sandwich structure of varying thicknesses.

Advanced research is being continued on the use of the laminates in nuclear power and missile applications. Bridgeport Brass Co.

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THE HIGH LEVEL OUTLOOK

FOR STRUCTURES ENGINEERING

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MARTIN
BALTIMORE

PRESSURE SWITCH

High temperature pressure switch rated for operation at 650°F in airframe, missile and rocket systems weighs only 11 oz. Unit uses all-welded stainless steel

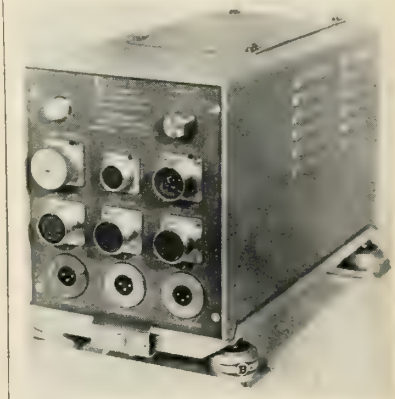


construction, an advanced type of snap-action switch element and a precision stacked-capsule sensing element, according to its producer.

The pressure switch is usable in standard aircraft fluid systems, air and hydraulic systems. Absolute-pressure version provides an adjustment range of 20 to 75 psia with a reset value, or difference between make and break, of 2 psi.

The Type 6576 switch adjustment is externally accessible through the inlet port. Rated proof pressure is 100 psi and burst pressure 150 psi. Contacts are SPST or SPDT rated at 1 amp. inductive. Overall dimensions are 1 1/ in. diameter by 3¼ in. long. Manning, Maxwell & Moore, Inc.

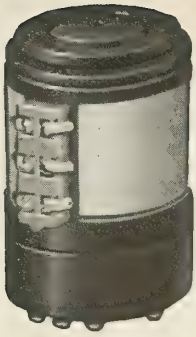
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INSTRUMENT SIGNAL CONVERTER

A three-channel system converts signals from 400 cps transducers to 0-5 volts dc for telemetering inputs. Conversion is by a crystal diode demodulator that eliminates all amplifiers from the signal circuits. Model 4-1103 provides a demodulated signal output with rated linearity of 0.5%. Dynalysis Development Laboratories, Inc.

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⅔ actual size

Honeywell Aero's MIG (Miniature Integrating Gyro) represents a scientific breakthrough in floated gyro design. Only 1.75 inches in diameter, and weighing less than 0.5 lb., its performance compares to hermetic integrating gyros three times larger. Primarily used in stable platforms, the MIG excels in short-time inertial and aided-inertial applications. Such miniaturized components typify Honeywell Aero's anticipation of advanced flight control system needs.

AERONAUTICAL DIVISION, MINNEAPOLIS-HONEYWELL



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POTENTIOMETER

A high performance potentiometer for severe environmental applications has a resistance of 30,000 ohms ±10% and withstands temperatures from —65°F to —275°F, 10g vibration from 10 to 1500 cps, and shock to 60g.

Model RP04-0101 weighs 2.5 oz. Distance travel is 4.13 in. Service life is 1,000,000 cycles. For mechanical positioning, the case and actuator have a vernier scale reading to 0.010 inch increments. Humphrey, Inc.



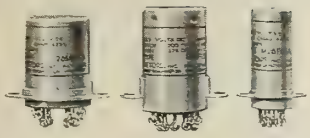
Circle No. 202 on Subscriber Service Card.

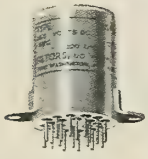
FREQUENCY DETECTOR

Narrow band frequency detector for telemetry and instrumentation applications provides an output current linearly proportional to frequency within a band width of 375 to 425 cycles. Units can also be provided to cover 10% bandwidth at any center frequency from 30 cps to 5 kc.



Output is suitable for operating a d'Arsonval instrument, servo-type recorder or a control curcuit. Linearity is within ¼% of midband frequency. Detector is hermetically sealed; operates from —55°C to 72°C; withstands 10g vibrations to 2000 cps and shocks of 30g in any direc-





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tion. Octal or other sockets can be provided. Units are 1½ in. diameter, 2 inches in seated height and weigh 6 oz. Airpax Products Co.

Circle No. 200 on Subscriber Service Card.

INPUT-OUTPUT TYPEWRITER

A new electric IBM typewriter designed for use as an input and output unit for the data processing field has been announced. It can be used in conjunction with measuring and recording instruments, scales and meters for engine resting, liquid flow measurement and wind tunnel research to provide a visual record.

Electro magnets and solenoids act as receivers of signals from a controlling device or computer to actuate the keyboard. Typing is done at the rate of 120 words per minute. Actuated functions include carriage return, spacing, tabulation, ribbon color control and others.

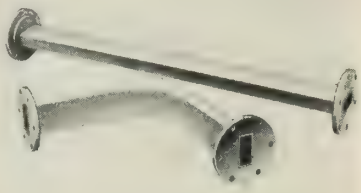
As an input device electrical impulses are transmitted by depressing the typewriter keys. International Business Machines Corp.



Circle No. 215 on Subscriber Service Card

HIGH-CONDUCTIVITY WAVEGUIDE

Oxygen-free high/conductivity copper is used in Airtron's waveguide components to minimize losses in long transmission lines. Now available are components such as straight sections, circular bends and adapters in the new material for WR-137 waveguide size.



For microwave relay systems operating in the 6000 mc region, the waveguide components of the new material have general application in indoor and outdoor cabinet applications since the high conductivity gives a lower insertion transmission loss for extended waveguide runs in these applications. Attenuation is between 2.0 and 2.4 db/100 ft. Airtron, Inc.

Circle No. 203 on Subscriber Service Card.

HIGH OUTPUT TRANSDUCERS

Resistance-type temperature transducers that give outputs up to 5 volts in telemetering and other applications are available in a variety of configurations for measurement of surface, fluid, and air temperatures.

Units cover temperature ranges of —320°F to 500°F with linearity rated at ±2%. Special units are available that cover up to 1600°F. Resistance values are 100 to 20,000 ohms. Either ac or dc bridge circuits may be used.

Each probe is supplied with a serialized calibration curve. Units are stated to meet MIL-5272 specification. Arnoux Corp.

Circle No. 214 on Subscriber Service Card

AMPLIFIER KLYSTRON

An amplifier klystron for use as the final amplifier of a high power microwave transmitter permits amplification of frequency, amplitude or phase modulated signals at power gains of about 50db. Featuring all-ceramic and metal construction, the VA-806 provides 2000 watts of continuous power in the 7125 to 8500 mc range.

The tube is water cooled and has a four cavity amplifier section tunable ±25 mc from specified center frequency. It features matched waveguide input and output, and low FM and AM noise. Varian Associates.

Circle No. 201 on Subscriber Service Card.

MISSILE MATERIAL

The Russell Manufacturing Co. has developed a new high temperature resistant Rusco woven material for rocket and missile parts insulation that is said to have stable performance characteristics under temperatures ranging up to 2,000°F.

Company reports it has developed techniques for weaving a ceramic fibre into tapes, sleeves, tubes and almost any other shape that might be required to meet particular applications.

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Capable of designing and evaluating for complex guidance systems and techniques as used in advanced missiles systems. Experience in electronics, inertia, radio command, infra-red forms of guidance equipment desirable.

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Experienced in UHF and microwave techniques and antenna design.

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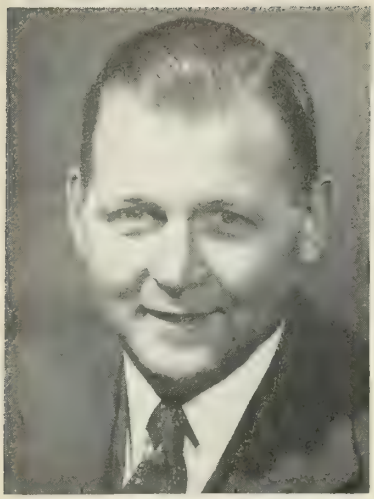
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HOLSCHUH

Carl G. Holschuh has been appointed president and gen. mgr. of Sperry Gyroscope Div., Sperry Rand Corp., succeeding **Charles M. Green,** retiring. **Mr. Holschuh** steps up from exec. vice president and gen. mgr.

Elmore P. Pillsbury, formerly chief of aeromechanical engineering for Fairchild Guided Missiles Division, Fairchild Engine and Airplane Corp., has been appointed chief engineer for the division.

Raymond J. Condon, mgr. of military sales for Minneapolis-Honeywell Regulator Co.'s Aeronautical Div., has been appointed vice president-government projects for the division.

Charles H. Godschall, manager of tooling and tooling engineering for the Government and Industrial Division of Philco Corp., was presented the Distinguished Service Award, the Navy's highest civilian award, "for outstanding work in the development of a new underwater weapon."

Capt. F. D. Pfotenhauer (USN, ret.) was appointed vice president of production and **D. C. Eaton** was promoted to vice president of program management for Reaction Motors, Inc.

James D. McLean succeeds **John B. Moss** as president of Hoffman Laboratories, Inc. **Moss** becomes chairman of the executive committee and remains a director of Hoffman Electronics Corp.

Glenn D. Maxwell was appointed asst. director of Consolidated Electrodynamics Corp.'s advanced electronic data laboratory, and **Lenard Johnson** was named supervisor, laboratory services.

William R. Whittaker, president of Wm. R. Whittaker Co., Ltd., has been elected chairman of the board of Telecomputing Corp.

Max M. Tall was appointed head of the reliability program for missile control projects at Radio Corporation of America's Missile and Surface Radar Dept.



PEARSON

John E. Lowe, formerly personnel manager for American Machine & Foundry Co.'s electronics division, has been appointed director of personnel and public relations of the new guided missile launching system plant in Rochester. **Robert W. Pearson,** manager of reliability control in the Missile and Surface Radar Dept., Moorestown, N.J., has been appointed deputy general manager for operations of the electronics div. in Boston.

Dr. Clarence Zener has been named director of Westinghouse Research Laboratories, after five years as associate director and a year as acting director.

Henry M. Haase was elected president and chief executive officer of the York Division of Borg-Warner Corp. at York, Pa. **Stewart E. Lauer** became chairman of the Board.

Bell Aircraft Corporation's Research Division announced the following appointments: **John F. Hawkins,** administrative mgr.; **Robert E. Hannel,** services mgr.; **William Shultz,** sales mgr.; and **Ronald E. Shainin,** contract administration mgr. The Avionics Division made these appointments: **Frank H. Andrix,** director of engineering; **Joseph D. Schantz,** assistant to division mgr.; **Robert C. Sellers,** sales mgr.; **Howard H. Herod,** contract administrator.

Maj. Gen. Francis H. Lanahan (USA, ret.) has been elected president of the Federal Electric Corp., subsidiary of International Telephone and Telegraph Corp.

Dr. C. B. Jolliffe, vice president and technical director of Radio Corp. of America, will head the new Special Systems and Development Dept. Other appointees are: **A. W. Vance,** chief systems engineer; **G. L. Dimmick,** chief development engineer; **A. C. Gay,** mgr., projects engineering; and **Dr. E. W. Pritchard,** administrative engineer.

Lewis F. Millett has been named to head radar development department of Bendix Aviation Corp.'s Research Laboratories division.

E. L. Rucks, principal engineer for Aerojet-General Corp., will head the new structural plastics group of its Solid Engine Division, whose principal activities are in the field of pressure vessels, thermal insulation and components for rockets and missiles.



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Navy Secretary Charles S. Thomas at Aerojet's Azusa plant discussing rocket power in general and the Polaris FBM engine in particular (?) with Dan A. Kimball, Aerojet president (right) and Assistant General Manager William L. Rogers (left).



Atoms-for peace visitors from Sweden. Representatives from the Swedish Atomic Energy Co. nuclear experts B. Nelsson, B. Swenson and R. Vestergaard. ACF Manager of Nuclear Energy Products Division, George Anderson (on right).



International Society of Aviation Writers plan First Congress to be held in Washington, D. C. April 3-6. Two hundred reporters, many from Europe and Latin America will learn about IGY and the Vanguard satellite program. Top left to right: Paddy Kavanagh, CANADIAN AIR REVIEW; Ed Kirschner, free lance, U.S.; Erik Bergaust, MISSILES & ROCKETS; James Cunningham, United Press. Bottom, left to right: Sydney Cooper, International Civil Aviation Organization, Montreal; Anthony Vandyk, AMERICAN AVIATION and MISSILES & ROCKETS; Ross Willmot, Executive Secretary, ISAW, Toronto. International aviation writers will set up headquarters at the Roosevelt Hotel in Washington. They will attend the American Rocket Society sessions to take place April 3-6. President of ISAW is Arthur Riley, Aviation Editor of the BOSTON GLOBE. ISAW was formed in San Francisco last year. It now has more than 300 members; more than 100 accredited US aviation reporters have joined.



•

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Accept this challenge and you can travel faster and farther than you ever thought possible on one of the most important programs in the free world today—North American's complete weapons system responsibility for the Air Force SM-64 Navaho Intercontinental Strategic Guided Missile.



DOUGLAS K. BAILEY received his BS degree from the University of California. He joined North American ten years ago as a senior design engineer. Today he is chief, Missile Design Section—responsible for missile design engineering and analysis. Doug and his family live in Long Beach where he participates in golf, bowling and sports car activities. He is currently organizing road races in Southern California for the Long Beach MG Club.

Unprecedented programs have been completed and more are to come. Others are being developed, modified and perfected as we enter another exciting phase following a successful flight test program at Patrick Air Force Base using a test vehicle known as the X-10.

The fascinating nature of this work has already attracted the world's best informed missile men. Top-tier men have opportunities in almost every field of engineering—including some of the most advanced work being done today in aerodynamics, thermodynamics, high temperature materials and aero-elasticity.

Solving these problems is bringing forth new formulae and new production techniques. One example is Chem Mill, the process of shaping metals—including titanium and newest alloys—to previously unattainable designs by chemical etching. This method reduces weight ... increases strength. The idea came from a North American Missile engineer.



Navy vet **GEORGE W. JEFFS** earned both his BSAE and MSAE from the University of Washington. About 9 years ago he started his professional career with North American as a junior aerodynamics engineer. Now, 5 promotions later, this 30-year old veteran of missile work is chief, Advanced Design Section. He lives in Downey, California with his wife and 3 children. His hobbies include fresh-water fishing and hunting for quail and pheasant.

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Recent graduate engineers can step into established groups. Experienced men will find even greater opportunities in the new groups that are being formed. And you'll do this in a management climate that stimulates personal growth and rewards it with responsibility, professional recognition and material benefits. Further, you can continue your studies with the aid of North American's Educational Refund Plan ... live and work in Southern California ... in near-ideal climate.

Let us know what kind of creative engineering interests you. (Please include highlights of your education and experience.)

Write today to: Mr. R. L. Cunningham, Engineering Personnel Manager, Dept. 91-2-MAR
Missile Development Division, 12214 Lakewood Blvd., Downey, California.

NORTH AMERICAN AVIATION, INC.



Photo courtesy of Northrop Aircraft, Inc.

High-speed control for high-speed missiles

Nowadays, target, aircraft, and missile speeds are too fast for human reactions. Automatic equipment makes ready, radar eyes take aim and a computer pulls the trigger.

Replacing men with machines on the firing line gives us a better chance for an interceptor kill or successful missile shot. And, today, we can't afford to miss. That's why reliability of every component is so important in modern fire control gear. And reliability is the main reason engineers—like those designing Northrop Aircraft's Snark missile (above)—so often pick Bristol's® Syncroverter® High-Speed relays (or the very similar Syncroverter chopper).

These high-speed relays have a normal life of billions of operations in dry circuit applications. They're available in SPDT and DPDT models with the typical characteristics listed below and in many variations.

And, of course, many critical applications other than fire control—such as air-to-ground telemetering, analog and digital computers, aircraft or missile navigation equipment, carrier current switching—can benefit from the outstanding reliability of Bristol's Syncroverter line. Write for complete technical data today. The Bristol Company, 173 Bristol Road, Waterbury 20, Conn. 6.61

TYPICAL CHARACTERISTICS

Temperature range: —55°C to 100°C
Operating shock: 30G; 11 milliseconds duration
Vibration: 10-55 cps (see below, Mounting); 10 G
Contact ratings: up to 35v, 45 microamperes
Stray contact capacitance: less than 15 mmfd
Pull-in time (including bounce): as low as 200 microseconds
Drop-out time: 300 microseconds
Life: Billions of operations
Mounting: Octal tube socket; others available, including types for vibration to 2000 cps.

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missile literature

ACID RESISTANT COATINGS. The Development of a Protective Coating Resistant to Nitric Acid and Hydrocarbons; by D. F. Siddall, E. Hillier, R. Garling and M. Gunther of U. S. Stoneware Co. for WADC; 116 pages; $3.00. Order Ref. No. PB 121217S. Review of research program to prove out X-200 resin or Kel-F 800 as a fluorinated material resistant to white fuming nitric acid encountered in acid tanks and assisted takeoff compartments of jet aircraft.

EXPLOSIVE VAPOR DETECTION. Study of Explosive Vapor Detection; by T. M. Shaw, F. K. Truby and W. R. Wood, Southwest Research Institute for WADC; 277 pages; $6.00. Order Ref. No. PB 121517. Report reviews results of survey of vapor detection methods and instrumentation with conclusion that no completely satisfactory principle of operation or sufficiently compact instrumentation exists for vapor detection in rocket-propelled aircraft. Recommendations are offered on possible methods of detecting fuel and oxidizer vapors, optimum detection methods and use of tracers.

HIGH TEMPERATURE MATERIALS. Cemented Borides; by American Electro Metal Corp. for Office of Naval Research; 140 pages; $3.50. Order Ref. No. PB 121346. A summary of experiments with Barolite IV, a promising high temperature material comprising several compositions of a chromium boride, Cr_2B and a Cr-Mo alloy. It is said to possess outstanding heat shock resistance, oxidation resistance and stress-to-rupture strength through 2,000°F.

TITANIUM CARBIDE. Iron Bonded Titanium Carbide, by R. E. Wilson, New York State College of Ceramics; for WADC; 39 pages; $1.00. Order Ref. No. PB 121323. Report describes techniques developed for hot pressing iron bonded titanium carbide into various shapes to enable determination of its physical properties. Although material was found inferior to nickel-bonded titanium carbide for use in aircraft power plants, extensive work with hot pressing is reported to have advanced that art. Iron-titanium carbide was effectively hot pressed with either the carbide or the metal as the continuous phase, depending on temperature used in the process. Also, molybdenum disulfide suspended in ethylene was found effective as a parting medium in hot pressing.

TITAIUM CLADDING. Roll cladding of base metals with Titanium, by P. T. Mataich and F. C. Wagner, Horizons, Inc.; for WADC; 36 pages; $1.00. Order Ref. No. PB 121479. Describes experiments with roll cladding of titanium to steel using a number of different metals as bonding agents. Best bond was obtained with a chromium plated layer on steel which was pressure-welded to titanium, but good bonds were also obtained by plating successive layers of silver and nickel on the titanium before cladding. Elements such as cobalt or nickel formed strong bonds to titanium—but in a very limited temperature range—a restriction which would make commercial work difficult, the report states. Although study indicated roll cladding is possible on a laboratory basis, the use of alloys as bonding agents is believed a possible means of producing higher strength bonds and further research is recommended.

DATA REDUCTION. Automatic Data Reduction—Part II, by R. S. Hollitch and A. K. Hawkes, Armour Research Foundation; for WADC; 80 pages; $2.00. Order Ref. No. PB 111928. A catalog of devices useful in automatic data reduction listing five categories of such devices commercially available or under development. Scope of listing is limited to equipment that is digital in nature. Categories include analog voltage to digital converters; shaft position to digital converters; digital plotters and digital to analog converters; miscellaneous digital devices; and, special tape recorders. An appendix lists producers of the devices.

DATA STORAGE: Superimposed Coding for Data Storage; by M. Taube, Documentation, Inc. for Office of Naval Research; 27 pages; $0.75. Order Ref. No. PB 121345. Report discusses methods of superimposing coding, or the recording of two or more codes in the same field, to facilitate information searching on machine sorted index cards.

ENVIRONMENTAL TESTING. Correlation of Natural Weathering and Sheltered Storage Exposure Tests with Simulated Environmental Laboratory Tests, by W. E. Laesch and W. W. Smith, South Florida Test Service; for WADC; 60 pages; $1.50. Order Ref. No. PB 121321. Report of investigation of the possible correlation between natural and laboratory-simulated weathering and storage tests on degradation of metals and plastics. Results showed no significant correlation between the simulated environmental tests and data obtained from natural weathering tests of the metals, or of lucite and laminated phenolics.

The Defense that Research Built

Working closely with various government agencies and aviation companies*, The M. W. Kellogg Company has participated in many important research and development phases of the rocket program. This has covered a wide range of missiles and rocket propulsion systems for Terrier, Talos, Snark, Sparrow, and Nike. Kellogg has also produced booster rocket cases and other components.

M. W. Kellogg's long rocket experience, supplemented by this organization's 50-year background of engineering and fabricating high temperature-high pressure industrial products, continues to provide valuable assistance to National Defense.



*Including the Navy, Army, Air Force, Allegany Ballistics Laboratory, The Johns Hopkins University Applied Physics Laboratory, and such well-known aviation names as Bell, Boeing, Convair, Douglas, Grumman, Lockheed, McDonnell, Northrop, Republic.



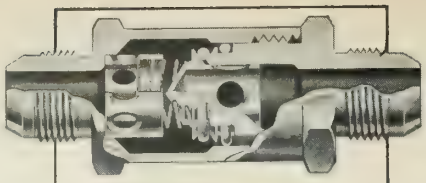
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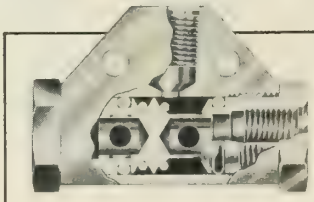
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industry briefs

THIOKOL CHEMICAL CORP. has received six new rocket engine development contracts from Army's Redstone Arsenal. Largest is valued at $442,743 for continued development of propulsion system for Raytheon *Hawk* I. Others involve XM19, XM19E1 and XM20 rocket engines ($329,180); *Lacrosse* rocket engine ($325,328); M58-E4 engine for Hughes *Falcon* ($41,-482); and continued R&D on large propellant type engines ($386,935).

BELL AIRCRAFT CORP. has been awarded two additional Air Force contracts totaling $22,040,047 for further R&D work on *Rascal* air-to-ground missiles.

BOEING AIRPLANE CO. has abandoned plans for a separate, fully-integrated guided missile division it hoped to establish near Richmond, Calif. Option on Ford Motor Co. plant there has been allowed to lapse and two additional options on local acreage will not be exercised. Reason: Air Force refused to support Boeing's plan for new division, hence *Bomarc* missile production will revert to company's Seattle plant with support from Wichita division and subcontracting firms.

McDONNELL AIRCRAFT CORP. reports earnings of $3,862,453 for first half of its fiscal year ended December

SPINNING WHEELS



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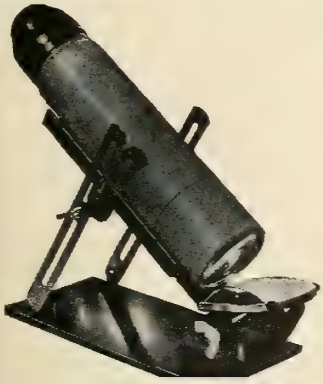
31 compared to $2,663,902 a year ago. December 31 backlog stood at $831,171,849 compared with $607,468,294 last year. Company is a key producer in *Talos* and *Green Quail* missile programs.

THREAT OF PROLONGED WORK STOPPAGE at Patrick AFB Missile Test Center ended abruptly February 1 when some 600 of 900 non-union workers striking against Pan American World Airways returned to work after one-day walkout. Their demand for vote on union affiliation remained unsettled at presstime.

AEROPHYSICS DEVELOPMENT CORP., Curtiss-Wright Corp. subsidiary which developed the *Dart* missile and HTV (hpersonic test vehicle), expects to occupy the first two of five proposed new buildings on February 15.

HUGHES AIRCRAFT CO. plans construction of a new $6-million plant for production of ground radar system components on a 475-acre plot near Fullerton, Calif. Hughes expects to employ about 2,000 workers there by 1958.

HALLAMORE ELECTRONICS division of Siegler Corp. has received an addition to an earlier contract with Convair's Astronautics division for system design, fabrication and assembly of equipment used in Convair's missile program.



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Edmund Scientific Co. was consulted by the coordinator of Visual Satellite Observations of the Smithsonian Astro-Physical Observatory regarding development of an optical instrument to meet the unique requirements of MOONWATCH. Needed was a low-cost instrument of greatest possible field—with the ability to observe faint objects with only slight magnification. Result—our Edscorp Satellite Telescope! Features: Wide (51mm) diameter, low reflection coated objective lens. 6 elements, extremely wide field, coated Erfle Eyepiece which, in combination with the objective, gives 5.5 power with a big 12 degree field and over 7mm exit pupil.

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Flight Test Operations

for ICBM and IRBM

Technical Staff and Project Engineering opportunities are open on the R-W Staff at the Air Force Missile Test Center, Florida.

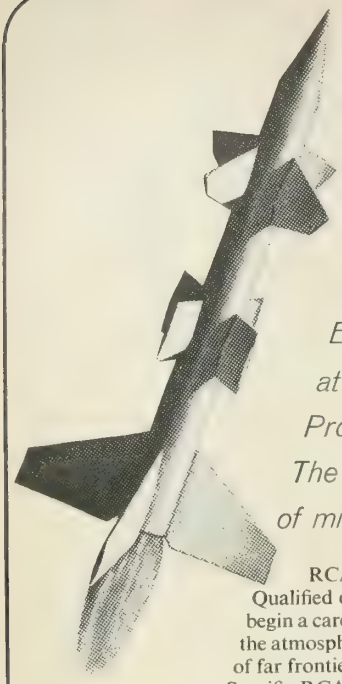
Ballistic missile test operations for ICBM and IRBM will explore new frontiers of missile flight. Providing technical direction in connection with these test programs is a significant aspect of R-W's systems engineering responsibility for these Air Force missiles.

The scope of R-W's assignment requires a Flight Test Staff of unusual breadth. Applicable technical fields include: geophysics . . . missile aerodynamics . . . propulsion . . . electronic and optical tracking systems . . . radio and inertial guidance . . . test data reduction and analysis . . . instrumentation systems . . . and ground support systems.

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Employment Manager, Dept. V-13B
Radio Corporation of America
Camden 2, N. J.

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Bomarc Test Personnel Get Pay Increase

Boeing Airplane Co. and International Association of Machinists-Local 2061 have agreed on hourly wage increases from 14½¢ to 20¢ for employes assigned to *Bomarc* missile test facilities at Cocoa, Fla.

The agreement covers workers who service and test missiles built in Seattle. The increases raise the rates of employes in Labor Grade A to $2.80 an hour.

NAA Missile Workers Get New Recreation Center

A new 6700-sq. ft. recreation center at North American Aviation's Downey, Calif. plant was opened recently for use by personnel of company's Autonetics and Missile Development divisions.

New Center includes a 375-person capacity auditorium, two club meeting rooms, office, kitchen, lobby and rest rooms.

Douglas Plans Conferences To Aid Engineering Force

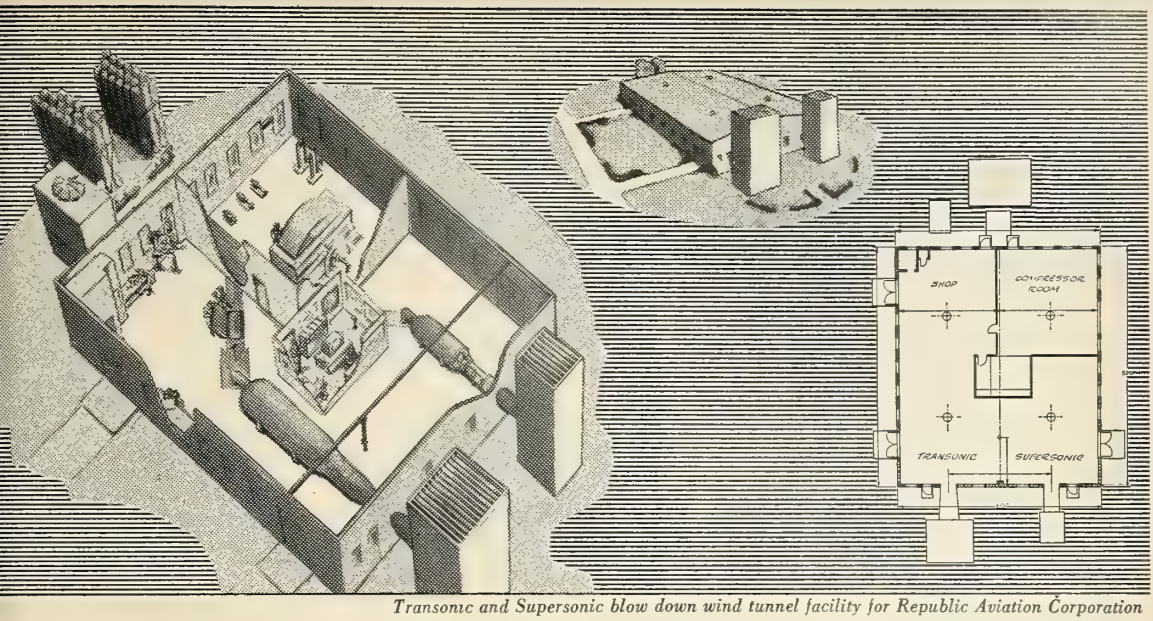
Douglas Aircraft Co. has held the first of a series of periodic inter-division conferences of design engineers —a meeting of chief aerodynamicists from five Douglas divisions.

The sessions, spearheaded by v.-p. engineering Arthur E. Raymond, are intended to take full advantage, throughout the Douglas engineering organization, of the diversified experiences at each of its divisions. In this way, Raymond feels, the overall Douglas engineering organization will be strengthened and improved.

On hand for the first session held recently in Tulsa, Okla. were O. E. Bottorff, asst. to Raymond, and these head aerodynamicists from Douglas divisions: W. B. Oswald—Santa Monica; K. E. Van Every—El Segundo; A. S. Church—Long Beach; H. F. Klecker—Tulsa and H. J. Gunkel—Missiles division.

GE Forms New Lab For Missile Research

General Electric Co. has formed a new Aerosciences Laboratory within its Missile and Ordnance Systems Department in Philadelphia. Its purpose: to conduct or direct applied research in specific fields of technology so that major improvements in missile weapons systems may be developed.



Transonic and Supersonic blow down wind tunnel facility for Republic Aviation Corporation

a special message to wind tunnel engineers and scientists

ANNOUNCING UNUSUAL OPPORTUNITIES WITH REPUBLIC'S NEW WIND TUNNELS SECTION OF THE R & D DIVISION

A new wind tunnel installation doesn't open every day!

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If you're presently a Director or Assistant Director of a wind tunnel installation, it means an opportunity to change pace —to express your ideas—and then implement them—in brand new facilities. And at the same time, to broaden your professional horizons.

Or perhaps you're a member of the operating staff at a wind tunnel. You've got experience, ability, intelligence. But you'd like a chance to get in on the ground floor of a new operation, with the most modern facilities at your command... and increase your opportunities from the very start.

If you're in any of these categories, you owe it to yourself—and your family—to check the following requirements and then contact us.

DIRECTOR: Should have 10 to 15 years' experience in the design, construction and operation of wind tunnels and related facilities, as well as complete staff administration.

STAFF: Preference will be given to people with direct or related experience, at all levels, in wind tunnel

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Please send complete resume, in strictest confidence, to:
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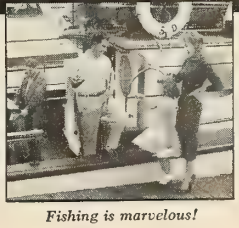
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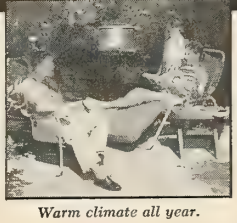
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More C/L Wage Hikes Paid Aircraft/Missile Workers

Cost of living wage increases totaling 6¢ an hour are being paid to aircraft and missile production workers in two west coast plants as the result of the BLS 118.0 index for December 15.

At Douglas, hourly workers will get a 2¢ increase added to the 4¢ received in past C/L allowances. Northrop Aircraft, Inc., producer of the *Snark*, reinstituted the cost-of-living allowance in December and is paying 6¢ in a single raise.

North American Aviation paid an additional 2¢ C/L adjustment late last month based on the November 15 index bringing its total C/L allowance to 5¢ an hour.

In addition to these immediate changes, deferred wage hikes negotiated in a number of two-year labor contracts will soon go into effect. At Lockheed, which recently received the Navy's *Polaris* missile prime contract, a 7¢ increase starts February 18. A 6¢ jump goes into effect at Chance Vought (*Regulus*) on March 12 and a 7¢ hike begins at Convair Pomona and San Diego (*Atlas, Terrier* and *Tartar*) on April 1.

Douglas will pay 7¢ effective March 18 at plants represented by United Auto Workers and on April 1 at those involving International Assn. of Machinists. Rohr Aircraft also pays 7¢ starting April 15 and Boeing a similar amount on May 22 at its Seattle plants. Ryan Aeronautical will pay a 7¢ increase on July 8.

Computers—and the Engineer Shortage

Electronic computers, properly used, could produce a "new look" engineer and may be the answer to the current shortage of scientists and engineers, a computer symposium jointly sponsored by New York University and International Business Machines was told recently.

Daniel O. Dommasch, president of Dodco, Inc., predicted that the mechanical brains could achieve this end via their creative power of more than 30 present-day engineers.

The Dodco executive said computers would free engineers and scientists from making the physical and mathematical approximations that are necessary and would replace today's educated guesses with accurate numerical solutions. This abandonment of approximation would bring industry into the age of true science, he added.

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MICROWAVE DEVELOPMENT ENGINEERS

To do development for the functional block diagram state to a complete bread board model. Theoretical and practical knowledge in the field is desired.

MECHANICAL DESIGN ENGINEERS

For the mechanical design of X-ray equipment, and for the designing of equipment to permit use of isotopes for medical treatment while protecting hospital personnel. An M.E. degree is required.

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To work with regional sales force on preparation of diagrams of the customers' organization, knowledge of the functions of the various elements, definition of procurement cycles, indication of important people and recommendations on over-all relations; detailed planning and coordination of sales strategy and proposal preparation; direction of contact efforts; liaison with Product Planner; and dissemination of product information.

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For the extensive application of present and future digital techniques to military problems. Applicants with background and interest in digital coding, digital programming, and in the necessary hardware to implement such systems would find immediate application in our present digital work and would be expected to originate future digital programs.

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Phillips Cuts the Cost of

OCKET PROPULSION

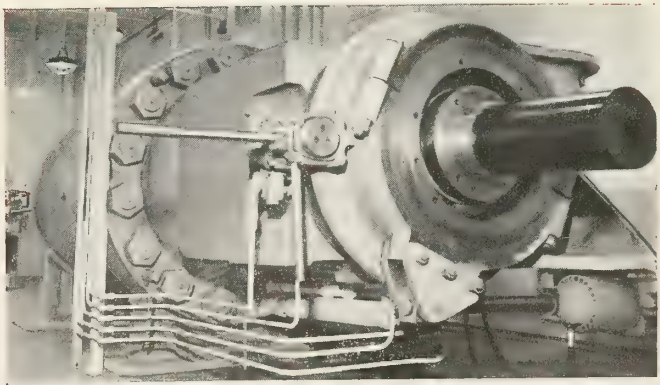
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Phillips Petroleum Company has made an important contribution to the economics of rocketry by developing a series of powerful, *low cost propellants* from readily available materials. The Phillips operated Air Force Plant 66, near McGregor, Texas, provides complete facilities for designing, developing, and testing solid rockets and propellants. You are invited to discuss your problems in propulsion systems, primary rockets, booster rockets, and related matters with our staff of skilled scientists and engineers.

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Giant extruders form solid propellants that are easily handled and can be stored for long periods.



tuned to the tempo of tomorrow

Open ears lead to the open thinking that made possible today's rocket powerplants. They are alert ears—ears acutely sensitive to the unsolved problems that must be conquered in designing powerplants for the vehicles of the future.

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Engineers, Scientists—Perhaps you, too, can work with America's *first* rocket family. You'll find the problems challenging, the rewards great.

Power for Progress

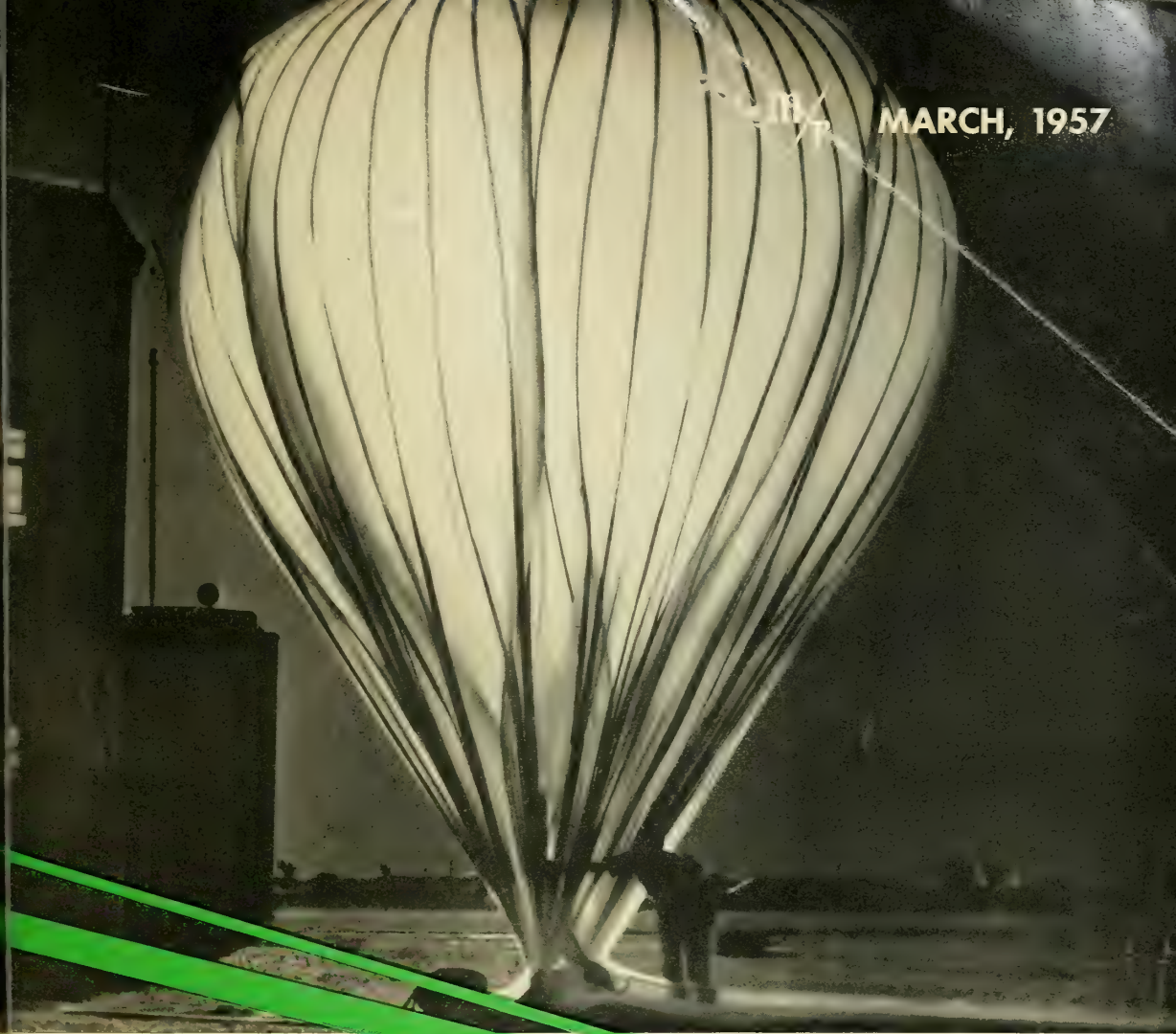
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MARCH, 1957

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

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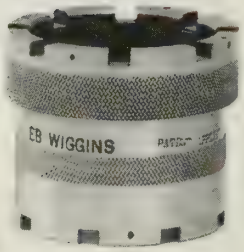
ROUNDUP ON UPPER AIR AND LUNAR RESEARCH ROCKETS

engineers agree

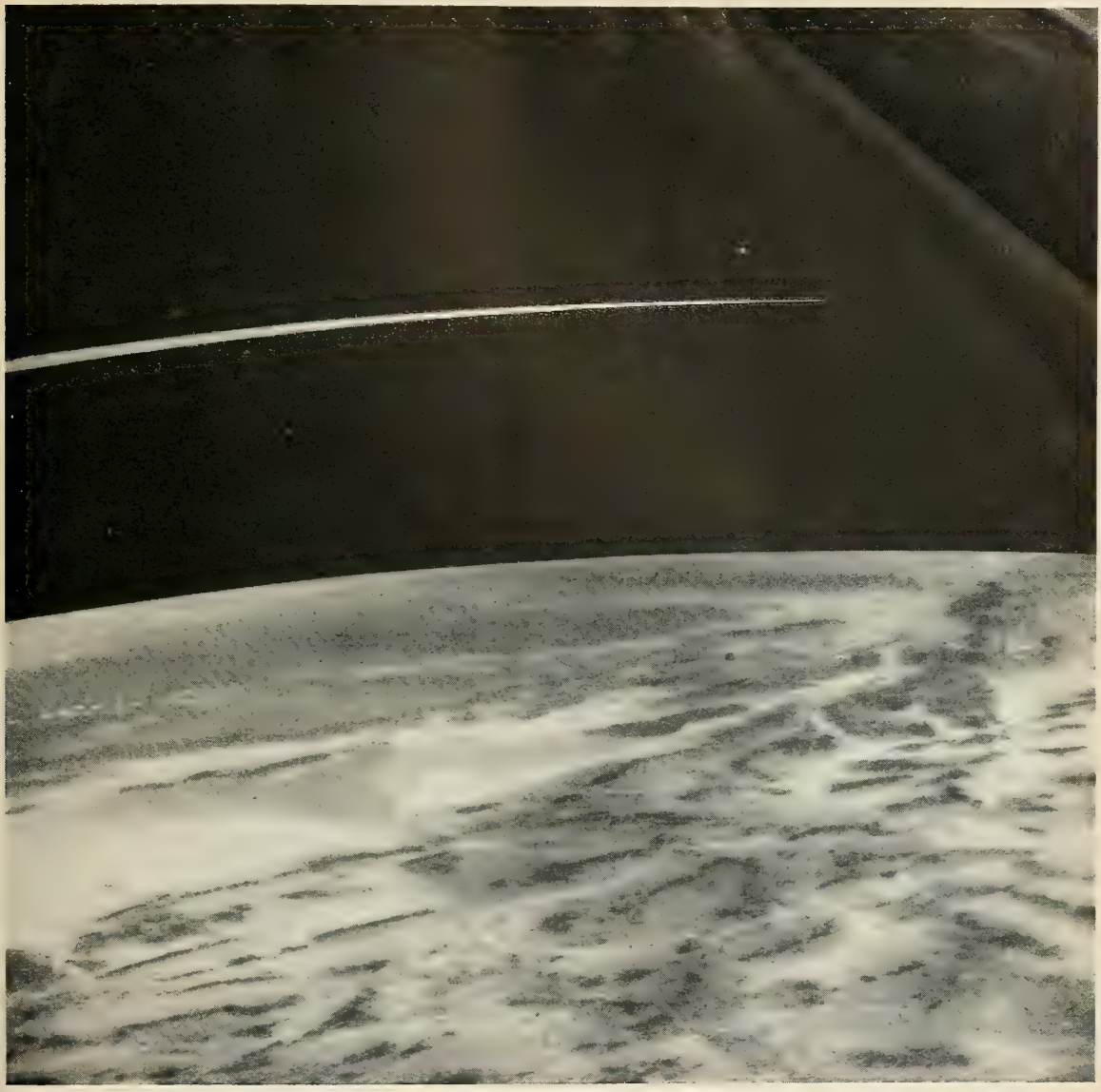
Not on how to mix a Martini —
nor necessarily on how to build
a missile platform —
but every day,
throughout the industry,
Engineers agree
on Wiggins Connectors.

Wiggins

The authority on connectors
Engineered for Reliability.



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ARTWORK BASED ON OFFICIAL U. S. NAVY PHOTOGRAPH

GLOBAL GUARDIAN

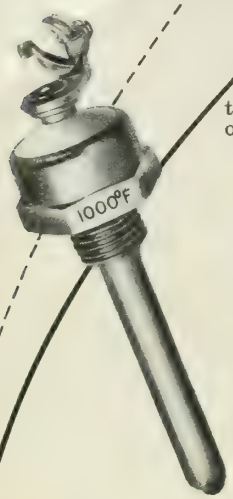
The Air Force's NAVAHO intercontinental strategic missile is near reality. How near is veiled in security. But we can tell you that it checks out as one of America's mightiest weapons in the struggle for peace. A major missile project executed in partnership with the U. S. Air Force, North American Aviation's NAVAHO development has accomplished the technical advances necessary to the production of an aerodynamic, supersonic, long-range guided missile. Bull's-eye accurate, and well nigh invulnerable to interception, the NAVAHO will extend this country's defense around the globe... at several times the speed of sound.

Engineers: write for details regarding challenging positions now open.

NORTH AMERICAN AVIATION, INC.

Los Angeles, Downey, Canoga Park, Fresno, California; Columbus, Ohio; Neosho, Missouri.

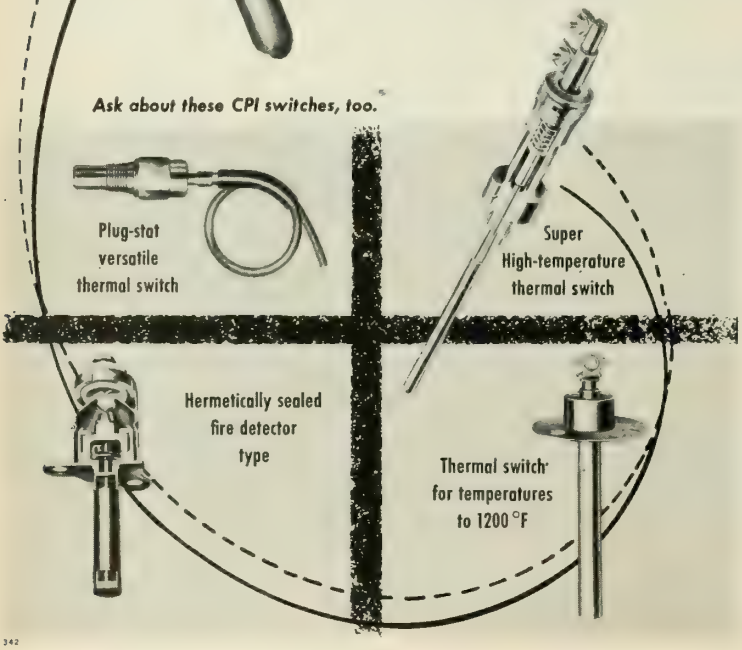
New CPI thermal switch is *Light and Lively*



This new lightweight (weighs less than one ounce) thermal switch features an operating differential of plus or minus only one degree with extremely fast response.

With an effective calibration temperature rating from —20°F +1000°F, it will even operate accurately when subjected to momentary undershoots to —80°F and overshoots to as high as 2000°F.

Wherever fast-acting, sensitive, thermally responsive regulation is required for control of dangerously high or low temperatures, this "LIGHT and LIVELY" switch will do the job accurately, dependably.



342

Ask our representative to tell you how CPI can help you solve your temperature control problem—and remember—when temperatures are high (or low) you can depend on CPI. Write for complete engineering data. Ask for catalog CA.

Control products, inc.

HARRISON, N. J.

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missiles and rockets

Magazine of World Astronautics

March, 1957 Volume II, No. 3

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DESCRIPTIVE DATA

- **SIZE:** 1 inch diameter x 2¼ inches long
- **WEIGHT:** 3.8 ozs.
- **FULL SCALE RANGE:** 40 to 400 degrees/second
- **LINEARITY:** 0.1% of full scale to ½ range, within 2% to full range
- **RESOLUTION:** 0.01% full scale
- **DAMPING:** Fluid damped, temperature compensated
- **PICKOFF:** Variable Reluctance type, 400 - 6,000 cps
- **MOTOR EXCITATION:** 6.3 volts - 400 cps, 26 volts - 400 cps, 9 volts - 1,000 cps



Putting the sting exactly where it belongs



Gnat Rate Gyro
Shown actual size

GOLDEN GNAT

Miniature Rate Gyros for Missiles and Aircraft

Here is a precision, minature rate gyro. It's tiny . . . measures only 1 inch in diameter and 2¼ inches in length. It's rugged . . . withstands 100G shock and 10G vibration to 2,000 cps. It has a record of proven performance.

Even under the most severe environmental conditions the Golden Gnat will perform as required. To make this possible many unique design details have been incorporated. One such detail is the Gnat's *gold plated* steel housing for improved corrosion resistance and positive hermetic sealing.

Wherever the need exists for high performance miniature rate gyros such as for autopilot stabilization in missiles and aircraft, antenna stabilization and fire control applications, the Golden Gnat is ideally suited. Write for Bulletin GN . . . Minneapolis-Honeywell, Boston Division, Dept 00, 1400 Soldiers Field Road, Boston 35, Mass.

MINNEAPOLIS **Honeywell** H HONEYWELL

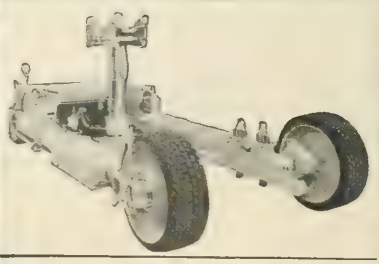
BOSTON DIVISION

HERE'S HOW
SOLVE YOUR



WALLACE HAMILTON'S job is designing equipment for storing and transporting a missile and positioning it for flight. Mr. Hamilton is Chief Engineer of the Special Products Division and under his control over 100,000 annual man-hours of engineering talent are available for developing transtainers and launchers that use Cleveland Pneumatic's years of experience in designing and making heavy-duty equipment, shock absorbers and special mechanisms.

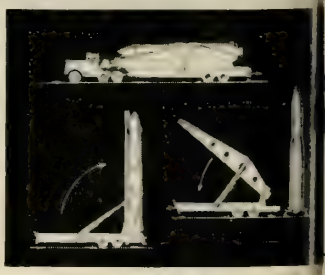
FOR ANY MISSILE, ANYWHERE.



Mobile heavy-devices lift built by Cleveland Pneumatic to raise a heavy weapon 150" from ground and position it within 1/32".



Servicing segment of missile work stand and tower as conceived by the project engineer of the Special Products Division.



Transporting vehicle with self-contai erector designed by the Spec Products Division, and capable of be built wholly in our shops.

OUR SPECIAL PRODUCTS DIVISION CAN MISSILE GROUND-SUPPORT PROBLEMS

Now, every sub-project connected with the ground-support phase of your missile program can be combined into a single contract.

Save man-power. Save time. Concentrate your available engineering and manufacturing facilities on your missile project. Cleveland Pneumatic will handle the complete ground-support project for you and will provide single responsibility for the entire project from the time the site is cleared to finished launcher ready to fire.

LAUNCHING TOWERS AND TEST STANDS—Years of experience in the design and fabrication of heavy-duty structures and highly precise mechanisms and controls that can delicately adjust and position massive missile and structural components enable Cleveland Pneumatic to design all types of launching and test stands for any size missile including ICBM.

PORTABLE LAUNCHERS—Portable units make fullest use of our experience as a leading manufacturer of handling devices, hydraulic movers, mechanical actuators, and the required systems of interlocking controls and safety devices.

SHIPBOARD LAUNCHERS—Pitch and roll can be compensated by combinations of Cleveland Pneumatic hydraulic cylinders and National Water Lift Division zero-positioning actuators, working under the control of NWL hydraulic valves and controls.

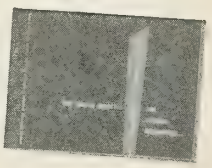
GROUND TRANSPORT EQUIPMENT—Vehicles for transporting the missile to the launching site can incorporate impact-absorbing devices perfected by Cleveland Pneumatic.

ON-SITE SERVICES—Architectural and engineering services for on-site construction are available from Cleveland Pneumatic under our one-responsibility contract with missile builders.

The Special Products Division is ready to start today on your missile ground-support project. The result will be equipment that will provide maximum ease of handling and smooth operation, reducing the manpower and time required for your ground-support operations.

Your missile project... and creative engineering

This new booklet outlines in detail the abilities and facilities of the Special Products Division. For your copy write on your company letterhead to Cleveland Pneumatic Tool Company, Special Products Division, Cleveland 5, Ohio.

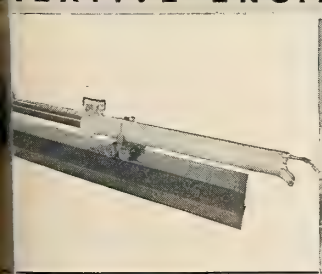


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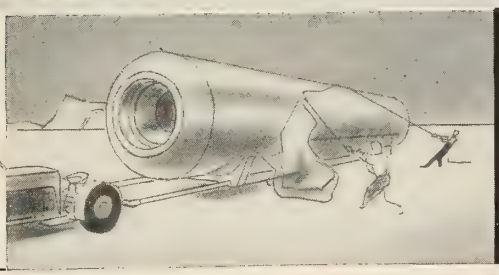
TOOL COMPANY • SPECIAL PRODUCTS DIVISION

Cleveland 5, Ohio

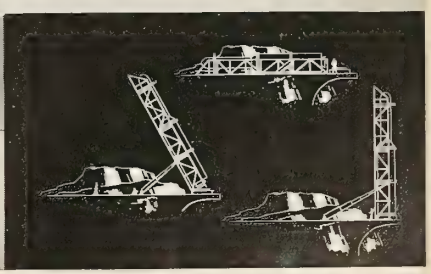
REATIVE ENGINEERING BY CLEVELAND PNEUMATIC



ge hydraulic actuator for support- ir a fighter plane underneath the fu lage of a B-36 Bomber.



Artist's rendering shows a storing-transporting vehicle suitable for over-the-road or airborne movement. It was designed and developed by Cleveland Pneumatic's Special Products Division for a large missile manufacturer.



Complete test stand and launching facilities for an intercontinental missile can be designed, engineered, produced and erected by our Special Products Division.



A Typical Tough Job

A guided missile component, previously contour turned, now being finished in inaccessible areas by contour planing . . . using a Three Dimensional Rockford Tracer Planer. By planing we are completing a section of a turned eliptical dome. Another typical and tough missile hardware job involving intricate and difficult machining techniques.

At Diversey Engineering you have the largest facilities exclusively devoted to your Guided Missile and Rocket Hardware problems. Contact us on your tough jobs.

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Diversey ENGINEERING COMPANY

10257 FRANKLIN AVENUE • GLADSTONE 5-4737
FRANKLIN PARK, ILLINOIS • *A Suburb of Chicago*

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Rockets Have Peaceful Uses

Military developments have so far obscured all other present and potential uses of rockets that it almost seems anachronistic to discuss their peacetime uses.

This issue of Missiles & Rockets, however, states the "Rockets for Peace" case very clearly.

Much of the valuable data obtained by scientists in recent years about the upper atmosphere—data affecting our everyday lives in such fields as geodesy, meteorology, navigation, medicine, and others—would not have been available without high-altitude rocket research.

From the bits of information obtained from instruments in upper-air rockets, research groups throughout the country are gradually amassing a complete analysis of phenomena which have determining affects on such things as magnetic storms, radio black-outs and various other aspects of air navigation and weather forecasting.

Most of this work is being done under auspices of universities and is handicapped by insufficiency of funds. Even the work on upper-air research by the Office of Naval Research and by the Army and the Air Force is relatively insignificant in scope because of lack of funds.

True enough, an extensive program is scheduled for the International Geophysical Year, but it is still limited in view of what *could* be done.

A well-organized large-scale program is called for. Based on rockets now available and the number of scientists who have expressed interest in upper-air rocket research, the results could have a genuine impact on our civilization and incipient conquest of space.

The possibilities are so extensive that only the government, in the final analysis, can organize, sponsor and finance a large-scale program.

All that exists today in the way of centralized activity is an informal group that calls itself the Upper Air Rocket Research Panel. The members get together now and then to discuss informally their experiments and experiences. It could well be that this informal panel is the proper nucleus for an expanded national program.

WAYNE W. PARRISH

letters

What Is Lintz Basalt? Why Does It Defy Gravity?

To the editor:

The column "Missile Miscellany" of the February 1957 of MISSILES & ROCKETS contains a statement concerning the properties of a material referred to as "the silicate, Lintz basalt." According to this, Lintz basalt generates heat spontaneously at 2.36×10^4 calories per hour per gram, and in free fall won't accelerate at 980 centimeters per second^2. I am sure you will agree the latter in particular is an amazing quality.

I would like to obtain more information concerning Lintz basalt.

I enjoy reading MISSILES & ROCKETS and find it contains a great deal of interesting and valuable information.

Dr. Paul W. Kruse
Senior Research Physicist
Minneapolis-Honeywell Regulator Co.
Hopkins, Minn.

To the editor:

If you have further information on item 2, Missile Miscellany department, page 99, February 1957 issue, it will be greatly appreciated.

G. M. Greene
Asst. to Vice President-Engineering
Hughes Aircraft Company,
Culver City,
California

To the editor:

In reading MISSILES AND ROCKETS, Feb. 1957, a short paragraph in the Editor's Column, page 99, stated among other things, *"The silicate, Lintz basalt . . . in free fall condition does not accelerate at 980 cm/sec^2"*

. . . Any further information that you have on this matter would be appreciated.

Mr. Charles Summes.
2186 47th St.,
Los Alamos, N. Mex.

To the editor:

In the February issue of m/r in the "Missile Miscellany" column on page 99, you made the statement, "why in free fall (the silicate, Lintz basalt) won't accelerate at 980 cm/sec^2." . . . I would like to see your source.

Incidentally, I enjoy your magazine very much. This latest issue on Russian missiles is excellent.

Leslie M. Bagnall
5840 Coleman Street
Fort Worth, Texas

To the editor:

In answer to your questions in your "Missile Miscellany" column in the February issue of m/r: Has anyone ever used modern theory to explain why the silicate, Lintz basalt . . . may I suggest that there may be a correlation between these phenomena and those observed in the so-called Biefeld-Brown Effect . . . and that the answers to your questions might properly be found in the current research that is now going on with regard to "anti-gravity" . . .

I think it would be very interesting if you would report on current progress in "anti-gravity" research.

Clifford B. Haughton, Jr.
Senior Development Engineer
Gas Turbine Department
Lycoming Division
Avco Manufacturing Corporation
Williamsport, Pennsylvania

The work with Lintz Basalt was performed by Charles Francis Brush and was later checked out by the National Bureau of Standards. The reference for the item in "Missile Miscellany" is as follows: The Proceedings of the American Philosophical Society; Vol. 65, April 23, 1926, a paper by Brush—Ed.

Glad Missiles May End War

To the editor:

. . . I am a civilian instructor in electronics fundamentals at Lowry AFB in the guided missile school and I felt quite encouraged by your optimism that missiles and rockets may be the means of ending wars . . . The senior instructor in our branch subscribes to your magazine MISSILES & ROCKETS and we find that it enables us to gain a much broader view of the whole industry than we could otherwise . . .

George James Pritchette
850 Oliver St.,
Denver, Colo.

Builds Solid Fuel Ramjet

To the editor:

. . . We at Experiment Incorporated were very pleased to see the mention of solid fuel ramjets by Alfred Zaehringer in "Propulsion Notes" (December m/r), since this is a subject close to our hearts.

The initial investigation of this engine type in the United States was made by Experiment Incorporated and Continental Aviation and Engineering Corporation. Later, Experiment Incorporated conducted a research and development program for the Navy Bureau of Ordnance which included flight tests, in January 1952, at NOTS China Lake.



These tests represented the first successful supersonic flights of a solid fuel ramjet (contrary to m/r's information that ". . . SF ramjets have been 'flown' only in test stands . . ."). Incidentally, both the PTV—N—4e flight vehicle and the solid fuel ramjet engine which powered it were designed and fabricated by Experiment Incorporated. Attached is a photograph of the vehicle ready for launching.

Other pioneers in this field were NACA and the Bureau of Mines . . .

V. W. McMahill, Jr.
Contracts Manager
Experiment Incorporated
Richmond 2, Virginia

Would See Satellite Launch

To the editor:

I am a sophomore in North Platte Senior High School and am very much interested in Missiles and Rockets. I would like to be present at the launching of the Satellite in Florida. Would you please give me the address of whom to write for further information regarding whether I could secure permission to be present at the launching.

Thanking you very much in advance. I enjoy your magazine MISSILES & ROCKETS very much and have increased my knowledge greatly through your magazine

Robert D. Stensvad
811 E. Third St.,
North Platte, Neb.

The Department of Defense is horrified at the thought, but maybe if enough people write requesting permission to see Vanguard take off, something will be done to make it possible. Write to: Cmdr. V. C. Thomas, Navy Press Desk, Office of Public Information, Department of Defense, Washington 25, D.C.—Ed.

Why No TV in *Vanguard?*

To the editor:

What with all the talk of establishing tracking systems for the satellite program, I'm a little surprised to read that nothing has been mentioned about installing a TV or movie camera within one of the satellites to provide us earth-bound creatures with a view of our earths' area as the satellite goes whizzing by. Has this been thought of and found impractical, or what? TV cameras are available which are small and powerful; and movie cameras, also small and able to operate by remote control, could be jettisoned automatically and parachuted to earth before the satellite burns itself out. Just curious.

R. Paulson
332 Prospect
La Jolla, Calif.

It would take a satellite weighing 100 lbs. to carry a TV camera and power supply. The current launching system is designed for only 21 lbs. USAF is working on camera equipped satellite. —Ed.

Would Banish LOZ, LOX

To the editor:

. . . Your recent "Propulsion Notes" by Alfred J. Zaehringer (m/r, December 1956) contained a reference to liquid ozone that stirred the cobwebs of my memory and recalled a shattering experience that occurred back in the early days (some ten months ago) of ozone research.

I refer to Mr. Zaehringer's coinage of the word "LOZ" as a contraction of "Liquid Ozone." One of our research engineers, brought up in the LOX school of rocket technology, boldly prepared a report that not only pushed back the frontiers of science, but also tried to

expand the confines of lexicography by mating the initial letters of "liquid" and "ozone" and giving birth to "LOZ."

The blessed event was viewed with disdain by an Ivy league chemistry professor who reviewed the report and commented as follow:

"——Now, turning from the sublime to the ridiculous, we have the question of lox and loz. I understand the derivation of the word lox as you use it, but I do feel that the salmon should have a voice in this matter. This business of loz is louzy. In your recent communication there is difficulty in separating 1 oz. and loz. It would also seem much better English if this word would be loze, but that makes it even more ridiculous, because people will think we are a theater chain of the same name.

Yours for Fowler's Modern English Usage."

LOZ thereupon died a painless death. The rebirth was inevitable, but we write in hope (but hardly expectation) that we can kill off the little offender once and for all . . .

Stephan Kidd

Solar Is Big Missile Supplier

To the editor:

. . . Congratulations on MISSILES & ROCKETS. I have just had the pleasure of seeing your December issue and wish to congratulate you on the material it contains as well as the interesting way in which it is presented. The chart "Subcontractors', Guide to Missile Production and typical Contractors," appearing on page 130, was of particular interest. We were somewhat surprised to note that the Solar Aircraft Company's name was omitted from this chart.

Solar's interest and activity in the missile field extends back for some years. We participated in the original development and manufacture of the *Hermes* missile and the *Corporal* rocket engine. Our activities in the missile field have continued to grow. Not only do we manufacture missile components for Aerojet-General Corporation, Jet Propulsion Laboratory and Rocketdyne, a division of North American Aviation, Inc., but we also manufacture the fuselage for the Falcon missile on a subcontract for Hughes Aircraft Company.

Fred S. Hage, Jr.
Director of Public Relations
Solar Aircraft Company
San Diego, Calif.

Would Reproduce m/r Article

To the editor:

. . . I thought it an excellent job and you may be sure that it has received favorable comment from many of our people.

May we trouble you once more for written permission to reproduce? I'd like to distribute copies of the General Medaris article and the one on the Aeroballistics Lab to interested personnel . . .

Gordon L. Harris
Public Information Officer
Army Ballistic Missile Agency,
Huntsville, Alabama.

High School Rocket Engineers

To the editor:

After reading the article on "Education . . . for the Missile Age" by Kurt R. Stehling, I felt that another phase of missile education which has been in most cases sadly neglected, should be mentioned. This is the phase including amateur study and experimentation which is presently being carried on at the high school level by many individuals.

Among these is the Seattle Astronautical Research Society, a group of high school students interested and presently majoring in science with a slant toward rocketry. This group, of which I am a member, has been studying astronautics for over 2½ years, and has carried on experimentation for the past 1½ years in static testing of rocket motors.



With the help of the Northwest Section of the American Rocket Society, and companies in various parts of the nation, we have been able to gain a wealth of knowledge and practical information on the science of rocket motors.

However, the attitude of complete indifference shown by some large corporations to our endeavors has made us question the extent of demand for scientists and engineers in the field of missiles and rockets.

I believe a well-supervised, nationwide program for potential missile engineers should be organized to catch interest where it counts most: At the point in high school at which students decide on vocations and colleges.

Leon Leonard, Research Director
The Seattle Astronautical Research Society
17347 Densmore Ave.,
Seattle, Wash.

Keep up the good work, Leon—Ed.

Solid Rockets Not So Safe

To the editor:

With reference to your article, "Break-up in Army-Navy Jupiter Program," I fear you are guilty of some unnecessary over-simplification in describing the advantages of solid propellants. In particular, I refer to the following:

> "The solid rocket doesn't require the outer shell or container. It doesn't require the propellant insulation gear nor any additional booster or torpedo powerplant. Pressurization requirement is insignificant.
>
> "Furthermore, because of the water resistance, a missile moves rather slowly underwater. It burns only a small amount of propellants before popping out of the sea; the water back pressure on the combustion holds the burning back."

Published data on solid propellants, both composite and double base types, indicate an increase in burning rate, rather than a decrease, with an increase in pressure. Of course the "mesa" type discontinuity exhibited by double-base propellants tends to minimize this dependence of burning rate on pressure. The effect of initial propellant temperature on its performance has been one of the primary disadvantages of its use. Some . . . of the propellants in use are extremely hygroscopic and require extreme care in handling and packaging . . .

Matthew J. Pastell
2210 W. 169th Pl.,
Torrance, Calif.

Missile Reliability Road Show

To the editor:

I read with great interest your Industry Highlights Section of MISSILES & ROCKETS issued in December, 1956, in particular about the Reliability Road Show that the Hughes Aircraft Company has provided for their subcontractors.

We of the Bendix Missile Section are completing a second Reliability Road Show . . . featuring a new movie producted by Bendix entitled *"Talos*—Flight 440." This movie deals with workmanship problems and their effect on the overall reliability of the *Talos* Missile... this show explained in the layman's language the meaning of reliability to the *Talos* workers . . .

Questionnaires were submitted to workers . . . soliciting comments. These comments . . . pointed out that normal aircraft standards that have been widely accepted by the industry are not adequate for the missile industry.

The information supplied by these questionnaires indicated that many intangible benefits have been brought about and we are certain that over-all missile reliability will benefit from the fact that each worker in the *Talos* program now has a better understanding of the importance of top workmanship and the necessity for personal responsibility on his part.

R. R. Wendt
Project Engineer
Reliability Department
Bendix Aviation Corp.,
South Bend, Ind.

Who's On Top?

To the editor:

One of our subscribers to THE ENCYCLOPEDIA AMERICANA has requested information which you may be able to supply.

The subscriber would like to know "What is the record height attained, in miles, by a man-made rocket or missile. I'm interested in distance straight up, rather than horizontal distance traveled."

We would appreciate any help you can give us with this matter. Thank you.

Margaret M. LaSala,
The Americana Institute.
2 W. 45th St.
New York 36, N.Y.

The official record is held by a two stage vehicle consisting of a V-2 and a WAC-Corporal fired from White Sands, New Mexico, in December of 1949. It went 250 miles up. However, the actual record—unofficial because it hasn't been publicly announced by the Pentagon—is held by a Jupiter-C missile fired by the Army Ballistic Missile Agency from Patrick Air Force Base on September 20, 1956—680 miles which would seem to be more out than up.—Ed.

Where do you belong in



Computer Circuit Design Engineers plan electronic circuitry for advanced airborne analog and digital computers . . . design linear and pulse circuits employing transistors, tubes, magnetic devices. Opportunities also exist in airborne power supply design, or to develop new techniques for marginally checking computer performance. *Do you belong on this team?*



Computer Logical Design Engineers determine the systems outline of a computer and its inter-connection with external equipment. Close liaison is maintained with mathematical support, circuit design, packaging and test engineers. Computer speed, memory size, configuration and arithmetic structure are tailored to requirements of weapons systems. *Do you belong on this team?*



Systems Evaluation Engineers test and evaluate electronic analog and transistorized digital computer systems design for aircraft; evaluate new systems and improvements to insure compliance with specifications and Air Force requirements. Other assignments: tie-in testing of peripheral equipment, liaison with design, development and field engineering. *Do you belong on this team?*



Harry Branning (center): B.S.E.E. 1950, Syracuse. Design Engineer in circuit design, 1951; October, 1954, promoted to Associate Engineer; April, 1956, promoted to Staff Engineer, Systems Planning. In June, 1956, appointed Project Engineer and Manager of the 110 Computer Circuit Design Department; discussing the performance and packaging details of a transistorized read amplifier.



William Dunn (standing): M.E. 1950, M.S.E.E. 1952, Stevens Institute. Technical Engineer, 1955; April, 1956, promoted to Associate Engineer; August, 1956, transferred to Development Engineering in charge of Logical Design for digital computers in advanced weapons systems; here discussing Boolean Algebra method of optimizing the logical design of an airborne digital computer.



Eli Wood (left): B.S.E.E. 1950, Connecticut. IBM Customer Engineer, July, 1950; September, 1952, transferred to ACL Field Engineering. February, 1954, in charge of Field Engineering at Hunter AFB; May, 1955, Associate Engineer; appointed Project Engineer, Manager of Systems Evaluation in August, 1956; here investigating a problem in radar data presentation set evaluation testing.

The brief records of the men cited above indicate only a few of the exciting activities right now in IBM Military Products. This division, organized 18 months ago, has grown enormously. A small-company atmosphere prevails. Men work in small teams . . . individual contributions are instantly recognized. Promotions occur frequently.

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IBM Military Products?



Systems Engineers oversee the engineering support provided by the Systems Coordination and Specification Group to the factory on the AN/ASB-4 Bombing-Navigational System. Air Force requirements are analyzed and the resulting engineering changes evaluated to determine effect on system performance and accuracy. Mathematical error analyses are run. *Do you belong on this team?*



Systems Analysts anticipate performance and recommend design criteria before and during development of equipment. Later, they compare dynamic performance accuracy and reliability characteristics with what has been anticipated. Other assignments include Digital Computer Systems Engineering, Input-Output and Analog-Digital Conversion Engineering. *Do you belong on this team?*



Quentin Marble (left): B.S.M.E. 1951, Syracuse. Joined IBM in 1951; promoted to Design Engineer in 1952; May, 1955, promoted to Associate Engineer, and then to Project Engineer, Manager of the Systems Coordination and Specification Group, Production Engineering Department, in February, 1956; shown here describing a unique cooling design to a new employee in his group.



Monroe Dickinson (left): B.S.E.E. 1952, W.P.I.; M.S.E.E. 1954, M.I.T. Technical Engineer in analog and alternate computer techniques for weapons systems, 1952; Associate Engineer responsible for systems design and analysis, 1954; December, 1955, Staff Engineer, responsible for research planning; here reviewing set-up on laboratory analog computer of a sampled data control problem.

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HUMAN ENGINEERING
INSTALLATION
CIRCUIT DEVELOPMENT
POWER SUPPLIES
TRANSISTORS
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TEST EQUIPMENT
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TECHNICAL PUBLICATIONS

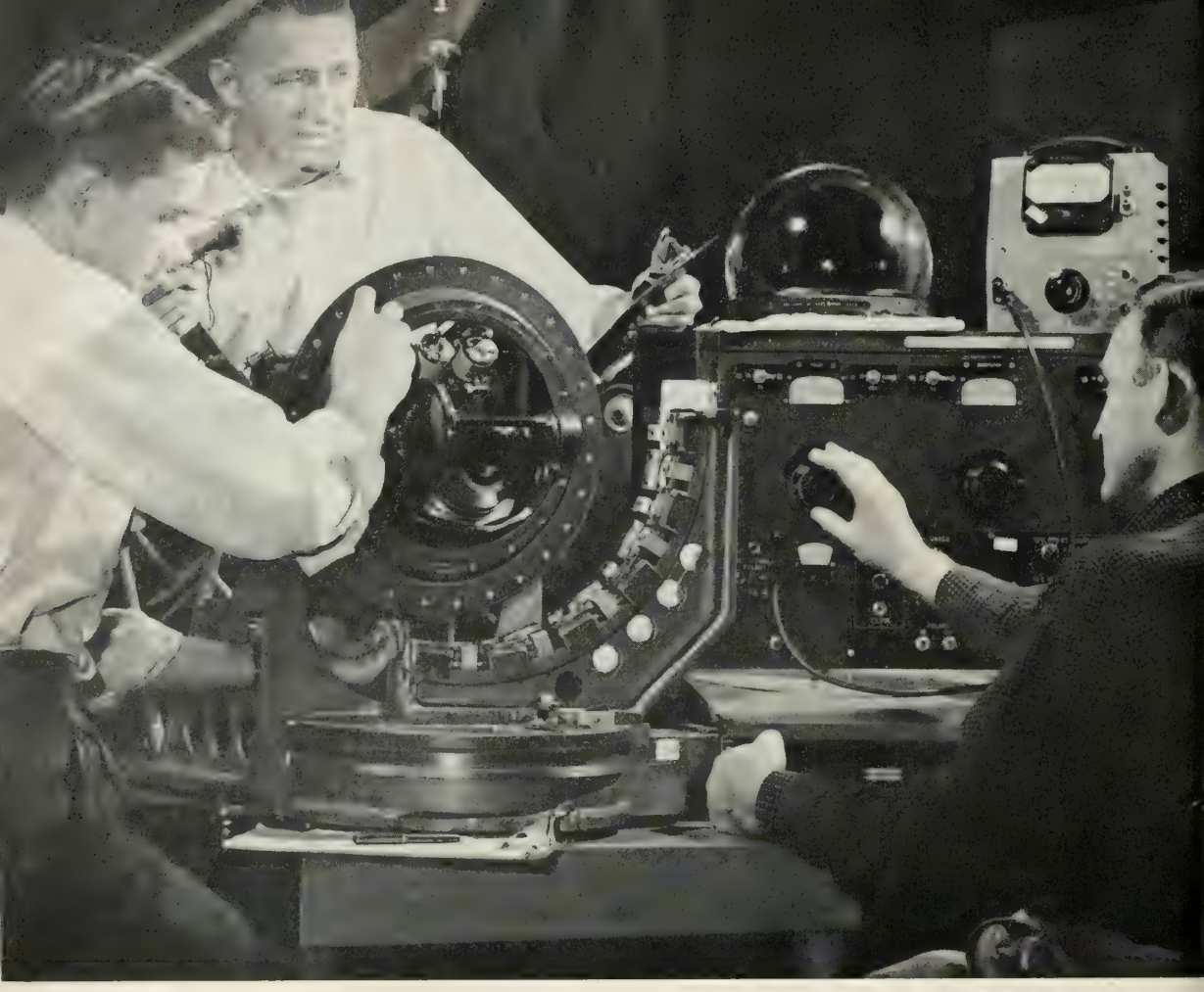
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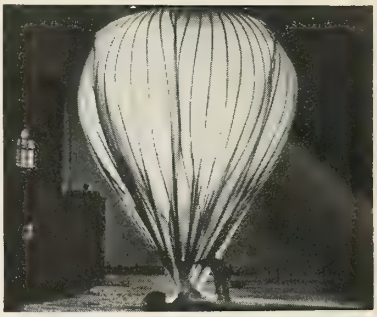
industry spotlight

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next issue:

U.S. AIR FORCE LONG-RANGE MISSILE DEVELOPMENT

cover picture:



Few could have guessed that a carnival toy of the Bourbon Court of France would be a high-step to space. Then it was smoke-filled, silk and gaily printed. Today's high altitude rocket research balloon is a polyethylene giant. m/r's cover shows a General Mills, Inc., balloon readying for pre-dawn launch. On page 50, Otto C. Winzen, modern balloon pioneer and Winzen Research, Inc., (WRI) President, tells how they probe the ionosphere.

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Las Cruces, New Mexico
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Patrick Air Force Base
Cocoa, Florida
Holloman Air Development Center
Alamogordo, New Mexico

AGE:
15 years in missiles; 37 in aircraft.

EDUCATION:
An engineering company managed by engineers — such as Donald W. Douglas, B.S., Aeronautical Engineering (M.I.T.); F.W. Conant, B.S., Civil Engineering (Cornell); and A. E. Raymond, B.S., Mechanical Engineering (Harvard), M.S., Aeronautical Engineering (M.I.T.), and Ph.D. (Hon.) (Polytechnic Institute of Brooklyn) — and with key staff positions held by graduate engineers, physicists and mathematicians, many with advanced degrees.

EXPERIENCE:
Pioneers in missile research development and production since 1941.

Major contractors for air-to-surface, surface-to-surface, air-to-air and surface-to-air missile systems.

Designers of auxiliary equipment to transport and launch guided missiles.

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Now responsibile for nine separate missile projects — including such "veterans" as Nike I (1945 to present) and Sparrow (1947 to present).

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REFERENCES:
The U.S. Army, Navy and Air Force.

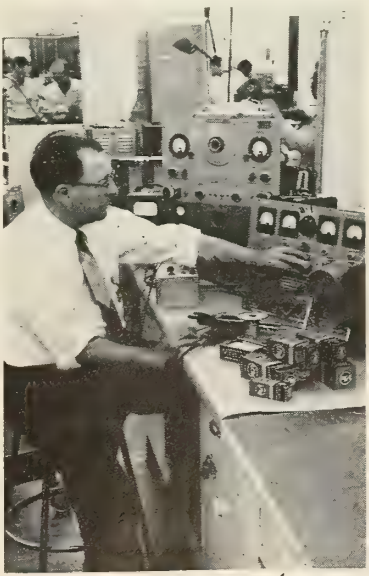
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when and where

MARCH

Nat'l Conference on Aviation Education, Mayflower Hotel, Wash., D. C., Mar. 7-9.

Nuclear Congress & Int'l Atomic Exposition, Convention Hall, Phila., Pa., Mar. 11-15.

IAS Flight Propulsion Mtg. (classified), Cleveland, Ohio, Mar. 14-15.

IRE National Convention, Waldorf Astoria Hotel and New York Coliseum, New York City, Mar. 18-21.

151st National Meeting of the American Meteorological Society, University of Chicago, Mar. 19-21.

American Society of Tool Engineers, Silver Anniversary Annual Meeting, Shamrock Hilton Hotel, Houston, Tex., Mar. 25-27.

10th Western Metal Exposition & Congress, American Society for Metals and others, Ambassador Hotel and Pan-Pacific Auditorium, Los Angeles, Mar. 25-29.

Educational Colloquium on Radiation Effects on Materials, sponsored by ONR and Glenn L. Martin Co., Johns-Hopkins University, Baltimore, Md., Mar. 27-29.

APRIL

SAE Aeronautic Meeting and Production Forum, New York City, Apr. 2-5.

Spring Meeting, American Rocket Society, Sheraton Park Hotel, Wash., D. C., Apr. 3-6.

British Radio and Electronic Component Show, Grosvenor House and Park Lane House, London, England, Apr. 8-11.

Annual Industrial Electronics Educational Conference, sponsored by IRE, Armour Research Foundation, Ill. Institute of Technology, Chicago, Ill., Apr. 11-13.

Southwestern IRE Conference and Electronics Show & Nat'l Simulation Conference, sponsored by IRE, Shamrock-Hilton Hotel, Houston, Texas, Apr. 11-13.

IRE PGTRC National Symposium on Telemetering, Sheraton Hotel, Phila., Pa., Apr. 14-16.

Symposium on Nondestructive Tests in the Field of Nuclear Energy, Morrison Hotel, Chicago, Ill., Apr. 16-18.

Second National Industrial Research Conference, sponsored by Armour Research Foundation, Conrad Hilton Hotel, Chicago, Ill., Apr. 24-25.

MAY

1957 Electronic Components Symposium, sponsored by IRE, DOD and National Bureau of Standards, Morrison Hotel, Chicago, Ill., May 1-3.

Spring Meeting and Exhibit, Society for Experimental Stress Analysis, Hotel Statler, Boston, Mass., May 1-3.

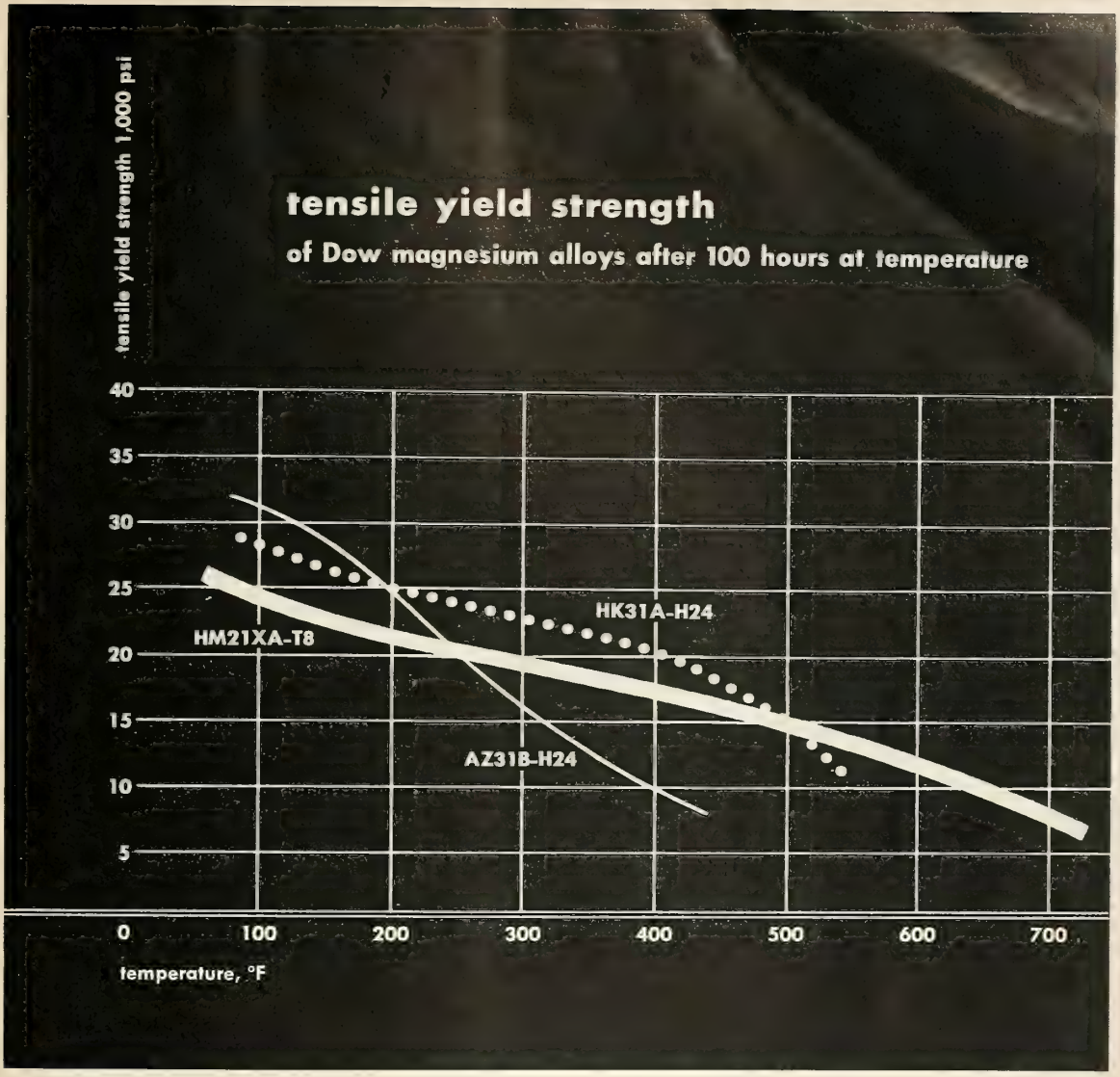
National Telemetering Conference, Hotel Cortez, El Paso, Texas, May 27-29.

JUNE

First Annual National Technical Career Conference, Sherman Hotel, Chicago, Ill., June 8-12.

Fourth International Automation Exposition and Military Automation Exposition, (Richard Rimbach Associates), Coliseum, New York City, June 9-13.

National Conference on Military Electronics, sponsored by IRE PGME, Sheraton Park Hotel, Wash., D. C., June 17-18.



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book reviews

The Zeppelin in the Atomic Age. *By Edwin J. Kirschner, 100 pp. $3.50, The University of Illinois Press, Urbana, Ill.*

The rigid airship (or zeppelin) may be with us again, this time with nuclear-powered engines. Certain obvious uses for the atomic-powered rigid airship are pointed out—as a missile launching platform and anti-missile defense weapon.

The author makes a strong case for the redevelopment and use of the rigid lighter-than-air aircraft. He cites facts and figures showing that there is a place in the commercial transportation picture for aircraft that is faster than the steamship and can carry more than the airplane. Since national policy greatly influences the total transportation system, he proposes an overall national transportation agency that would also encourage the development and operation of the extra long-range zeppelin.

The military rigid airship would be versatile and capable of performing many jobs where speed is not the sole criterion. Other important factors are also taken into account: cost, capability, utilization, safety, and dependability. Radar-equipped rigid airships could provide a relatively permanent electronic-detection umbrella as early-warning outposts to the Western Hemisphere and around the world. Present airborne and ground-radar equipment have their operational limitations, while an early-warning rigid airship, powered by nuclear engines, would be capable of carrying powerful radar equipment, and of extending the range of our early warning system a reported 500 miles.

To make the early-warning airship "combat ready," it could be designed to house, send off, and hook on to parasite jet fighters, and operate platforms for firing rockets and missiles in defensive and offensive military operations. Such a weapon Kirschner predicts would be capable of radar surveillance and to interdict an attack before it could reach the Western Hemisphere, at the same time dealing an immediate counteroffensive. The existence of such a force as this encircling the American continent would aid in making an attack unprofitable to the enemy anywhere within the range of these aerial 'minute men' platforms.

The author particularly sees the atomic-powered airship as an aerial reconnaissance ideally suited for the kind of patrolling suggested by President Eisenhower's "open-sky" plan. It would be used as a platform in conjunction with jet-photo aircraft or satellite platforms for special inspection assignments requiring close examination of critical areas for indefinite periods of time.

The first part of the book is devoted to an illustrated history of lighter-than-air aircraft. Our airship history has shown that the United States has lacked experience and interest in the development of the rigid airship. Until now, the United States has built only three rigid airships and flown four. The fourth was the *Los Angeles* which was built in Germany and successfully operated by the U.S. until its retirement before the Second World War. Germany has built more successful rigids than all the rest of the world combined—approximately 150—and is commonly accepted as the foremost airship nation in history.

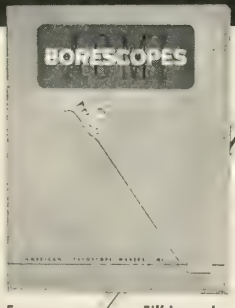
The spectacular death of the German hydrogen-filled *Hindenburg* at Lakehurst, New Jersey, in 1937 sparked a staggering blow to zeppelins in the U.S. Thirteen persons were killed. At the time, the U.S. National Advisory Committee for Aeronautics reported that airships had helped aviation development tremendously and could contribute much more of value to the future of aeronautics. They emphasized that the airship should not be allowed to stand idle while other branches of aeronautics are developed.

An economical and safe aircraft is pictured by Kirschner for the atomic-powered, helium filled, rigid airship. The book is highly interesting, and merits consideration for vocational purposes.

A Technical Dictionary of Rockets and Astronautics. *By Glauco Partel (A.I.R.), 107 pp. $1.61, Published by Istituto Poligrafico Dello Stato G. C., Rome, Italy.*

This paper-bound dictionary lists over 1300 rockets and astronautics terms in Italian, German, English and French in four side-by-side columns. Included also are word finder lists in all four languages as well as extension conversion tables from the metric to the English system and back. It is a complete presentation in all four languages and should be a very valuable addition not only to technical libraries but to the collection of handbooks and the like scientists and engineers keep on their desks.

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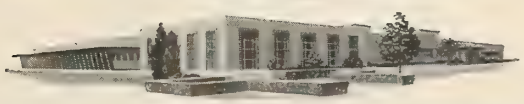
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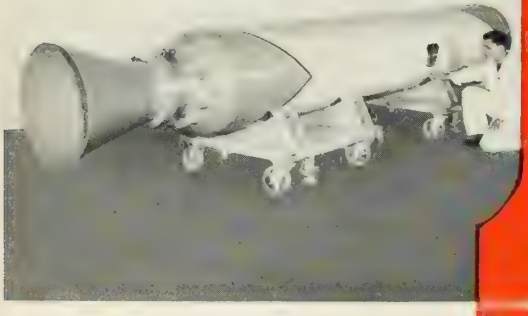
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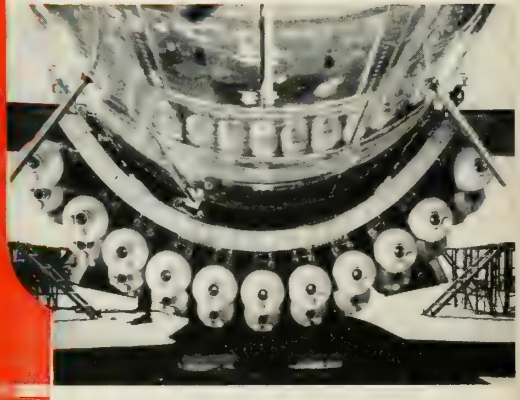
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The M15 JATO loaded on Boeing B-47. The first JATO to meet rigid Air Force performance tests. (Boeing Airplane Company photo.)

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USAF to Start Moon Rocket Program

Vehicle Circling The Moon Will Be Ready In Less Than Five Years; Companies Rush Proposals; Convair Heads List Of Hardware Bidders

By Erik Bergaust

SAN DIEGO—What might turn out to become the most significant event of our century has been confirmed to m/r during the Convair/AFOSR space flight symposium here: the Air Force is getting ready to start a moon rocket program.

In an exclusive interview Brig. Gen. Hollingsworth F. Gregory, Head of the Air Force Office of Scientific Research, told this reporter the Air Force "probably will have a rocket circling around the moon in less than five years."

"Several moon rocket study contracts are in the works," the general said, "and it is imperative that we carry out these scientific research projects to stay ahead of the Russians. When I say that we will have a moon rocket in less than five years, it is a conservative estimate."

The general also confirmed that ICBM power-plants are likely to be used for the Air Force moon rocket, and that it might be considered a "logical step" to launch "modified" ICBMs toward the moon as part of the Air Force training program for ICBM launching crews.

During the three-day symposium m/r also learned reliably that Convair is heading the list of companies about to submit proposals for actual hardware contracts for Air Force moon rockets. Other companies include Lockheed, Marquardt, Boeing, Douglas, Martin, Grand Central Rocket and Systems Laboratories. Most of these companies are involved in moon rocket study work. Convair's proposal is said to involve a circumlunar vehicle with a 200-pound payload consisting of camera and "television" equipment.

The Rand Corporation, meanwhile, has been conducting a moon rocket *study* for the Air Force for some time, and other study contracts for the various phases involved in launching lunar vehicles have been let but not disclosed, although it is known that Systems Laboratories has an AFOSR contract.

In a banquet speech here Western Development Division Commander General Bernard A. Schriever indirectly confirmed the possible availability of ICBM engines, components and hardware for the forthcoming lunar rockets. He said that out of the tremendous IRBM/ICBM effort will come a wealth of design information and hardware that will be useful for other things beyond that for which they were designed. These airframe, propulsion, and guidance subsystems developments and the data which will become available as ballistic missile test flights are made, will make possible a whole series of follow-on projects.

"The same propulsive unit that boosts a heavy nose cone-warhead to 25,000 feet per second, could boost a somewhat lighter body to the escape velocity of 35,000 feet per second or to an orbital path around the earth, General Schriever said.

"Using the same number of stages, the ratio of thrust to weight would be greater by using a lighter payload, and higher accelerations and velocities could be reached before burnout. Or with our present state of knowledge, it would be relatively easy to add another stage. We have already done that successfully on our re-entry test vehicle, the X-17. The same guidance system that enables the warhead of a ballistic missile to reach its target within a permissible accuracy would also be sufficiently accurate to hit a target much smaller than the size of the moon, even at that increased range," General Schriever said.



Brigadier General Hollingsworth F. Gregory tells m/r how Air Force hopes to send rocket to the moon.

Two Inevitable Moon Rockets

According to some of the nation's top missile and rocket engineers here two different moon rocket projects will be attempted within the next few years. A relatively small rocket—such as has been studied by the Rand Corporation (see line drawings)—will be built to land on the moon's surface. A second type, the circumlunar vehicle, will be brought into an orbit that takes it around the moon and back to earth, although it will not be attempted to retrieve the rocket. "I think this is the kind of lunar rocket that we will attempt first," General Gregory told m/r. This vehicle might carry up to 200 pounds of electronic video tape recorder equipment. Pictures will be taken of the moon's unseen side while it is illuminated by the sun, and as the rocket "returns" to earth the stored information will be transmitted back to earth.

Tribute to Air Force Office of Scientific Research

General Hollingsworth F. Gregory, outspoken scientific-minded Air Force brigadier general, told m/r AFOSR's mission is one of fundamen-

tal, theoretical or experimental investigation to increase man's knowledge and understanding of the natural world and to "recognize the implications of new scientific knowledge upon weapon systems concepts." Its capability to carry out this mission is represented by scientists throughout the free world working in universities, in industry, in foundations, and in government agencies under approximately 650 research contracts totaling about $30 million awarded by his organization, he said.

Exploratory Research Provides Capabilities For New Concepts

"We define our program as one of exploratory research. This is research with a view toward adding to man's total knowledge, in our case in areas of Air Force interest. Exploratory research provides 'capabilities'—capabilities for developing new concepts of weapon systems that may revolutionize the art and science of aerial warfare. In the Air Force Office of Scientific Research, these capabilities are represented by some 250 laboratories spread throughout the worldwide scientific community.

"We are concerned with three Air Forces," General Gregory said. "First, the Air Force of today, next the Air Force of tomorrow or the next five to ten years, and, finally, 'the Air Force of after tomorrow,' which might well be operating space vehicles rather than B-52s. AFOSR is particularly concerned with this Air Force. It is quite conceivable that the nation which controls the space around our globe will control the peace on the globe."

"So, consequently," General Gregory continued, "information about space, that is, a scientific understanding of cosmic rays, ionization, temperatures, densities in space, is of the utmost importance to us. We must understand the natural laws that will dictate tomorrow's defense. Man is climbing higher and higher, and it seems probable that a system of man-made satellites—coupled with the moon—could well become the necessary weapons system needed to tell the other fellow to keep peace, or else . . .

Air Force To Stay Ahead Of Requirements At All Times

"This thing of sending rockets to the moon is a natural result of current research in the field of advanced studies of weaponry as well as investigation of the natural laws and challenges that we must pursue and understand . . . and don't forget: we have to stay ahead of requirements at all times, and our Air Force must have the very best at all times . . . instead of trying to catch up when we learn that the other fellow already has achieved something big," the general said.

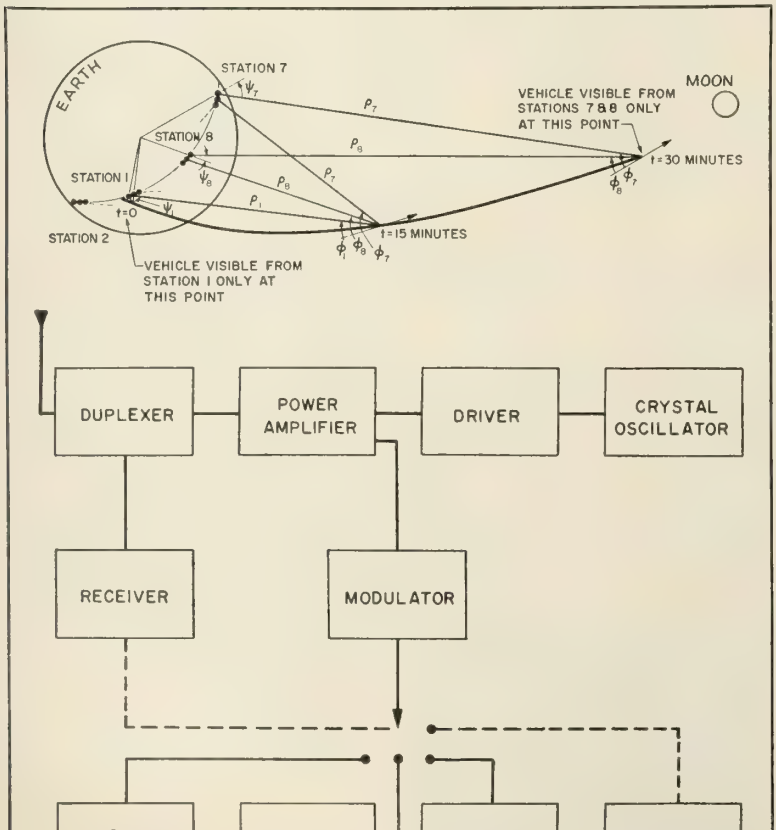
"There are several moon rocket study contracts in the works," General Gregory disclosed, "and it is quite possible that we may make some headway here when the first ICBMs become 'operational,' that is, when components such as the engines are tested and are ready to go. After all, it seems logical that the Air Force, when the ICBMs become operational, will want to train their launching crews and test their vehicles under realistic conditions—and a good way to do it might well be to send modified versions of these vehicles into orbits around the moon."

Asked whether Air Force lunar rockets will be designed to land on the moon General Gregory said it is possible the first lunar rocket will be designed to go into a semi-circular orbit around the moon to obtain scientific data.

Imperative for Air Force To Keep Up With The Russians

"This feat might well be accomplished within the next five years," he predicted. "And when I say five years I probably am quite conservative. Furthermore, several moon rocket study contracts have been in the works for some time now, and we visualize that it won't take too long before we can activate a lunar rocket program. It certainly is imperative that we keep up with the Russians in this respect since we know that they understand fully the concept of space operations and are extremely interested in space flight."

Says one rocket engineer: "The Air Force Office of Scientific Research certainly should be commended for its foresight and its interest in what may turn out to become man's greatest scientific adventure." *(See follow-up article on the moon rockets on page 82).*



Rand Corporation—a non-profit organization established to conduct research work for the Air Force—has released some information from its moon rocket studies. Top drawing shows flight path of small instrument-carrying rocket and location of tracking stations on Earth. Diagram illustrates proposed instrumentation for small moon rocket.

Huntsville Won't Give Up Fight for Jupiter

HUNTSVILLE, Ala.—News of the successful firing of the Jupiter IRBM ushered in the month of March in this old Southern city that finds itself the center of the Air Force-Army controversy—and the calendar found most of the inhabitants acting like lions.

The whole argument between the services as to the merits of the *Jupiter* and the *Thor* has been simmering throughout the community since Secretary Wilson issued his now-famous memorandum of Nov. 26th assigning responsibility to the Air Force for all missiles with a range of more than 200 miles. But little has been said publicly about it until now. Now, the lid is off.

"Charlie Wilson has put his foot in his mouth again—and this time I hope he chokes on it," declared the usually amiable editor of the *Huntsville Times*, the city's only daily. He was reacting to the statements of the Secretary earlier in the week regarding the "cancellation" of the *Jupiter* project. The "misinterpretations" and "clarifications" of his statements about the *Jupiter* and the *Thor* served only to raise the community's boiling point even higher.

There were reports that talent scouts from unnamed industries were seeking to lure away various members of the famous von Braun team of some 125 missile and rocket research scientists. Dr. von Braun himself, who is already under contract to Walt Disney in addition to other duties, was reported in a restive mood—but a check with him and with several of his associates brought the response that they were happy in Huntsville, that they had spurned many outside offers and that, income tax considerations being what they are, they would prefer to stay. However, as one put it: "We'd really like to go to the moon instead of aiming at puny targets 200 miles away."

The surging anxiety of the community was somewhat calmed by the assurances of Maj. Gen. John B. Medaris, commander of the Army Ballistic Missile Agency, that there would be no appreciable slackening of activity at the ABMA in the foreseeable future. Hiring at the Arsenal and ABMA continues unabated, and applications average 1,200 a month.

Meantime, the case of Col. John C. Nickerson became entangled in the hot discussions of Secretary Wilson's various remarks.

The community has stared with wide-eyed awe at the spectacle of the Colonel being escorted through town by armed guards when he comes in from the Arsenal to visit his attorneys.

As Secretary Wilson's latest press conference remarks were published here, there arrived on the desks of various community leaders registered letters from Army Secretary Brucker. The gist of these communications was that the Army's intelligence service had reported that these individuals had received copies of the noted brochure, "Considerations on the Wilson Memorandum" which was circulated to civic leaders and Senators and Congressman shortly after Wilson's memorandum of Nov. 26. Mr. Brucker asked that such copies as remained in circulation be returned to him or that he be given assurances that they had been destroyed. He referred to the brochure that Col. Nickerson is supposed to have released to "unauthorized persons."

Then on Feb. 28th arrived the vanguard of what bids fair to be one of the largest gatherings of nationally known newsmen to assemble in the South in some time. Their purpose was to find out when and where the court-martial of Col. Nickerson would be held and what the defense might be.

The next day, a Friday, two *Jupiters* were launched from Patrick AFB and on the Monday following, Third Army Headquarters announced its decision to go ahead with Col. Nickerson's court martial, probably in early April. In Huntsville there is widespread speculation that the case may not only develop into something like the Billy Mitchell case but provide as great a journalistic circus for the South as the Scopes monkey trial in nearby Dayton, Tenn.

The Colonel's civilian counsel will be Robert K. (Buster) Bell, of the Huntsville law firm of Bell, Morring & Richardson. Mr. Bell during World War II was top assistant to the late Brig. Gen. Edward Betts, also of Huntsville, who was chief legal officer to Lt. Gen. J. C. H. Lee of the Army Service Corps in the European Theatre of Operations. Mr. Bell in 1950 conducted a spirited campaign for Governor of Alabama and is noted throughout the state for his sharp legal acumen, biting wit and verbal resourcefulness.

With its phenomenal growth of the past six years threatened—from 16,000 to 60,000 population under the impact of the Arsenal and ABMA—the town has reacted in a manner understandable only to students of Southern psychology. A cotton mill with five modern steel and concrete buildings and an area of 800,000 square feet, plus a huge parking lot, became vacant when the Northern absentee landlord decided to sell off the machinery. Some 700 textile workers were laid off. Within the space of a week, 30 Huntsville citizens raised enough cash to purchase the property which is insured for $3,500,000. They are now offering this space to industries interested in the climatic, labor, water, TVA power and other advantages of the area.

The Army Guided Missile School, often overlooked here and elsewhere, will continue to train all the thousands upon thousands of officers and enlisted technicians who will be required as the nation takes the giant step from manned to unmanned defense. That may be ten years in the making, but 153 year-old Huntsville, the first capital of Alabama, can wait. It's betting most alert firms now engaged in aeronautics and astronautics will find it advantageous in terms of enlightened self-interest to arise and come to Huntsville.

A local wag consulting his almanac the day *Jupiter* flew read under March: "*Jupiter* will rise . . . in opposition."



NIKE HERCULES, Army's atom-loaded ground-to-air missile now undergoing final tests. Within the year NIKE HERCULES will begin to be integrated into the NIKE AJAX bases that now ring many major American cities. Note NIKE HERCULES' larger warhead and heavier boosters. It is claimed to be faster and higher than its predecessor.



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The Link simulator, which the Air Force recently incorporated into its state-side training programs, serves as a "stand-in" for the expensive Matador during simulated training missions. Using their own operational missile control equipment, guidance crews can direct the make-believe Matador from launching to a direct hit on an "enemy" installation . . . and the simulated mission is just as realistic as an actual one.

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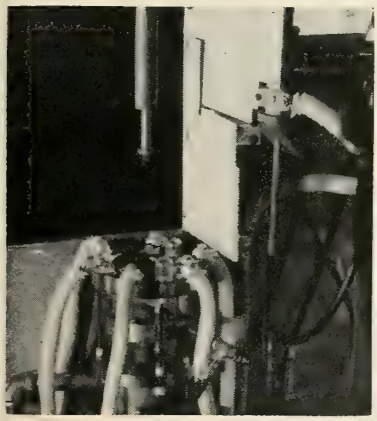
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Plasma Jets Give Minutes of ICBM Reentry Heat

In Los Angeles Giannini Research Laboratories reports development of a plasma jet with temperatures of 10,000°K. Simultaneously, the University of Chicago and General Electric's Missiles and Ordnance System Department at Philadelphia jointly announce a water stabilized arc plasma flow with temperatures exceeding 14,000°K (nearly 26,000°F) and velocities up to 4,000 ft. per second. The surface temperature of the sun is 6,000°K.







Top picture shows Giannini Research Laboratories' 10,000°K plasma jet in operation. In the middle is General Electric's water stabilized arc plasma flow producer, prior to test. Bottom: A nose cone model under test in GE unit glows white hot as it is bathed with atomic vapor at temperatures over 14,000°K.

Working with an input power of 3,000 kilowatts the stabilized arc has developed a heat transfer rate of 2,000 BTU per square foot per second about four diameters from the nozzle. This compares to 800 BTU obtained from rocket engine nozzles.

Both the GE and Giannini devices can be run continuously for minutes at a time.

Developed under the direction of Dr. T. R. Hogness, Director of the Chicago Midway Laboratories and Dr. L. Steg, Manager, MOSD Aerosciences Laboratory, the first water stabilized arc—a one-quarter inch model—was built in Chicago last July. Recently a one-and-a-quarter inch model went into operation. Present plans are to build a three-inch model which will require 8,000 KW of power. MOSD has built an evacuated test chamber for its arc in order to better control environment.

This arc is not new. Stabilized arcs go back as far as 1904 when Sweden used gas-stabilized arcs to make nitrous oxide. In 1922 H. Gerdien and A. Lotz of Siemens-Schuckertwerke, an electrical firm in Berlin, were the first to use the water-stabilized arc. Dr. Lochte-Holtgreven of the University of Kiel is a recent pioneer in the field.

The geometry used and the manner of extracting the plasma from the arc follows the experimental set-up of R. Weiss, Institute for Experimental Physics, of the University of Kiel.

Using air instead of water stabilization, plasma flow velocities in excess of Mach 10, heat transfer rates of over 6,000 BTU and still higher temperatures are anticipated.

Researchers consider that plasma jets are to heat transfer research what the shock tube is to hypersonic aerodynamic study.

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Quotable Quotes from Clark, Wilson, Rickover

Every winter when Congress gets back to work and the main concern of Government Departments is once again money, the tempo of things done and said quickens. Last month Navy missile chief Rear Admiral John E. Clark set forth the Navy's missile position; Defense Secretary Wilson defined the role of scientists in his Department; and Navy nuclear propulsion head Rear Admiral H. G. Rickover demonstrated that missile engineers aren't the only ones with "that" trouble. Here, in direct quotes, are some of their words:

JOHN E. CLARK: "We can't set up launchers in great numbers . . . our launchers must be capable of rapid reloading with a minimum of readiness time . . . Missiles must be capable of stowage in large numbers in confined magazines . . . Aerodynamic engineers . . . must get the absolute maximum out of small and folding wings and the aerodynamic body of the missile . . .

"The special problems faced by the Navy in developing guided missiles for the fleet has resulted in many cases of apparent duplication in programs between the Navy and the other services. I believe that in many of these cases the charges are unfair to all concerned. It doesn't make much sense for the Army, for instance, to have imposed special Navy problems on their contractors and in the case of the Air Force to have imposed our special aircraft requirements on their contractors. As a matter of fact, while the development costs were large, each missile, apparent duplication though it might be, contributed tremendously to the art in general and each produced much that the others were able to use . . .

"Mr. Wilson's 'Roles and Missions' memorandum of November last . . . simply restated for the Navy the policy that development and operational employment of ship-based intermediate range ballistic missiles would be the sole responsibility of the United States Navy . . ."

CHARLES E. WILSON: "The difference between an engineer and a scientist is perhaps not as great as some people try to make out. There is a question of invention comes into it, also. Most scientists are a little more theoretical; perhaps have delved a little deeper into higher mathematics and written papers on various kinds of advanced things, but most engineers understand the language of scientists, whether they are scientists themselves or not. The important thing here in the Defense Department is to have somebody in this assignment who has administrative and executive ability; understands how to cooperate with other people and coordinate work. The real majority of our research work and our engineering work is done in contractors' plants; a smaller amount of it in laboratories and arsenals and places like that; plants that are operated by the services. The Defense Department, itself, has practically no activities. So that to some degree, I sense that this assignment is a misunderstood job. The responsibility of the staff in the research and engineering and of the Assistant Secretary in charge of it and his deputy is to review and audit activities, to make reports to me, when we get into controversy between the services to attempt certain standardizations to be worked out with the services to eliminate duplication and overlapping of activities; to help establish an order of importance of some of our activities and advice on troubles and difficulties that we get into. And the Assistant Secretary of Research and Engineering has no authority to operate, as such. He simply advises the Secretary what he thought up after the staff makes a study, which should be done in a particular case, and whether it is done or not is up to the Secretary, and the services and the people that do it . . ."

H. G. RICKOVER: ". . . But one factor which today most severely limits our exploitation of nuclear power is neither legal nor governmental. It is not a lack of new ideas, nor even a lack of understanding of recently developed ones . . .

". . . New problems are being reasonably well solved . . . It has been very difficult to get sufficient effort directed toward the more conventional aspects of nuclear plants—the heat exchangers, the pumps, the valves, the instrumentation. Here normal engineering and manufacturing techniques have proved to be inadequate when applied to nuclear plants . . .

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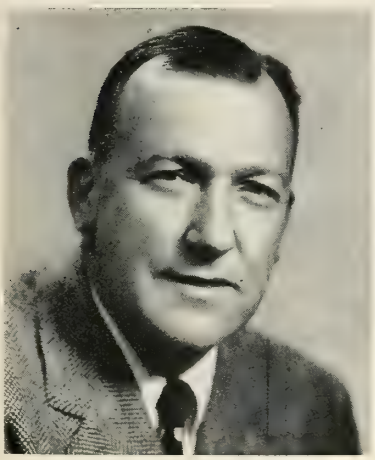
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U.S. Senators Due At ARS Meeting

The program for the American Rocket Society's Spring Meeting in Washington, D.C. is firmed up. Guest speaker at the banquet Saturday, April 6, will be Dr. Athelstan F. Spilhaus, Dean, Institute of Technology, University of Minnesota, and Member of the Executive Board of UNESCO. Several members of the Senate Armed Services Committee have been invited to attend.

ARS is introducing a series of sponsored breakfasts and luncheons with brief speeches and panel discussions. Among the sponsors are North American Aviation Inc., Grand Central Rocket Co., Harvey Aluminum Co., Chance-Vought Aircraft Co. and Reaction Motors, Inc. Speakers include Maj. Gen. David H. Tully, Ft. Belvoir Commanding General, discussing rocket pro-



ATHELSTAN F. SPILHAUS

pulsion and guided missiles in the atomic age, Dr. Theodore von Karman and a special panel provided by NAA.

The ARS program will include 16 papers on high-speed rocket sleds and rocket tracks. There will also be a session on Space Sociology with Dr. Wernher von Braun, Andrew G. Haley and Dr. S. Fred Singer among the speakers.

This is the first time the ARS meets in Washington, and, since it coincides with Cherry Blossom Week, many wives are expected to attend. The International Society of Aviation Writers meets simultaneously in the nation's capital.

Most significant feature of the Spring Meeting will be the Rockets and Satellite Exposition. Over 50 industry booths have already been signed in addition to exhibits by NACA, Army, Navy and Air Force.

ARS Spring Meeting Chairman, Andrew G. Haley told m/r: "We expect a record turn-out . . ." The meeting will be held at Washington's Sheraton Park Hotel April 3-6.

Russian Dogs Probe Upper Air

The Moscow newspaper Trud, February 16, described a series of rocket flights carrying dogs to an altitude of 110 kilometers. In the February 23 issue of Pomfomolfkaya Pravda more details were released wherein Professor Anatoly Bladolravo claims the Russians now know how to send men aloft in rockets. Bladolravo is Chief of the Technical Sciences Branch, Soviet Academy of Sciences.

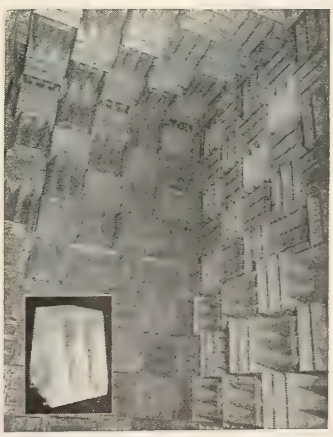
In the first group of dog-carrying rocket flights, which reached an altitude of 100 kilometers (62.1 miles), the dogs were put in an air-tight compartment in the rocket head, containing a system of "air regeneration." Equipment carried by the rocket automatically registered the temperature and air pressure in the compartment; also took the skin temperature, respiration rate and pulse of the dogs. A camera recorded the animals' reactions. Results showed that the dogs' physical condition during the flights did not change substantially, according to Pokrovsky. There was only a small deviation from normal in the pulse rate and character of respiration. Body temperature remained almost constant, and reflexes after flight were normal.

The second series of tests reached the maximum altitude of 110 kilometers. The dogs were placed in a non-airtight compartment in the rocket head. Two catapult capsules were installed in the compartment. Inside each capsule, a dog, not wearing an oxygen mask, was placed in a special "diver-like helmet." However, an oxygen supply "sufficient to keep a dog alive in the helmet for several hours" was attached to the catapult capsule along with a parachute device and recording instruments. Weight of the capsule was about 70 kilograms (154 lbs). The parachute allowed a vertical speed of approximately 6 meters (about 19.7 ft) per second. The dogs were placed in the helmets daily for steadily-lengthened periods of time for two months preceding the rocket flights.

Launchings usually took place three to five minutes before sunrise. At the top of the trajectory, the rocket head containing two dogs separated from the body of the rocket. At a height of 80-90 kilometers, during free fall, the dog in the right capsule was catapulted. Speed of capsule ejection from the rocket head was about 700 meters (2,296 ft) per second. The parachute opened three seconds later at a height of 75-85 kilometers. "For an hour the animal was subjected to the direct effects of all external factors in the upper levels of the atmosphere."

The rocket head, freed of the right capsule, continued its rotating free fall. The second dog, located in the left capsule, was catapulted at an altitude of 35-50 kilometers at a speed of 1,000-1,500 meters per second. This free-fell to an altitude of three-four kilometers, where its parachute opened.

During the entire rocket flight, up to the moment of catapulting the capsules, a camera took pictures of the animals. According to *Trud,* some dogs made several rocket flights. It said that no animals were killed by the experiments. They were about the size of cocker spaniels.



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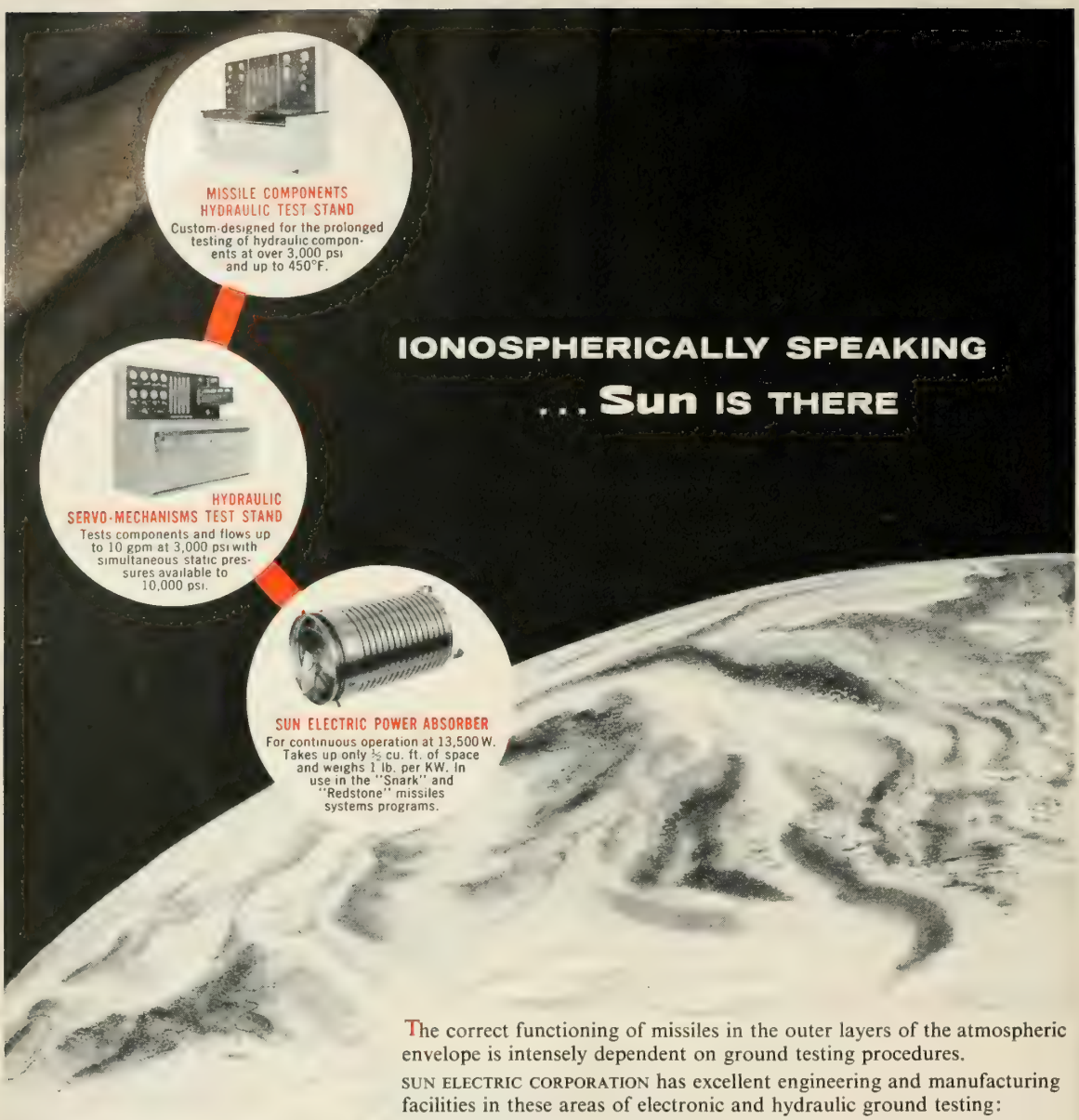
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Regulus II Trainer Has Boundary Layer Control

Chance Vought's better-than-Mach 1.5 *Regulus II* made its first official public bow at the Navy League meeting this month in Washington, D.C. Though faster by far than its predecessor, *Regulus I*, the 57-foot long bird still incorporates wheels in the test and training version. It has a 20-foot wing span. Missile placed on display was number seven.

Well along in its land test program at Edwards Air Force Base, Texas, preparations are now being made to launch it at sea. It's expected that it will become operational in about a year. It will fit *Regulus I* submarine stowage and launching gear with only slight modifications.

The supersonic Chance-Vought missile incorporates many proven *Regulus I* components, such as the same Sperry auto-pilot; same beacons; and the same system for recovery.

In landing after test, *Regulus II* hits the runway at a hot 250 knots. It has no flaps; uses only a drogue parachute to slow it down. Even at this high landing speed it still requires boundary layer control for the wheeled versions. Photographs to the left show the air intake for this system. Bottom photograph shows the boundary layer exhaust duct. This will not appear on the operational missile.

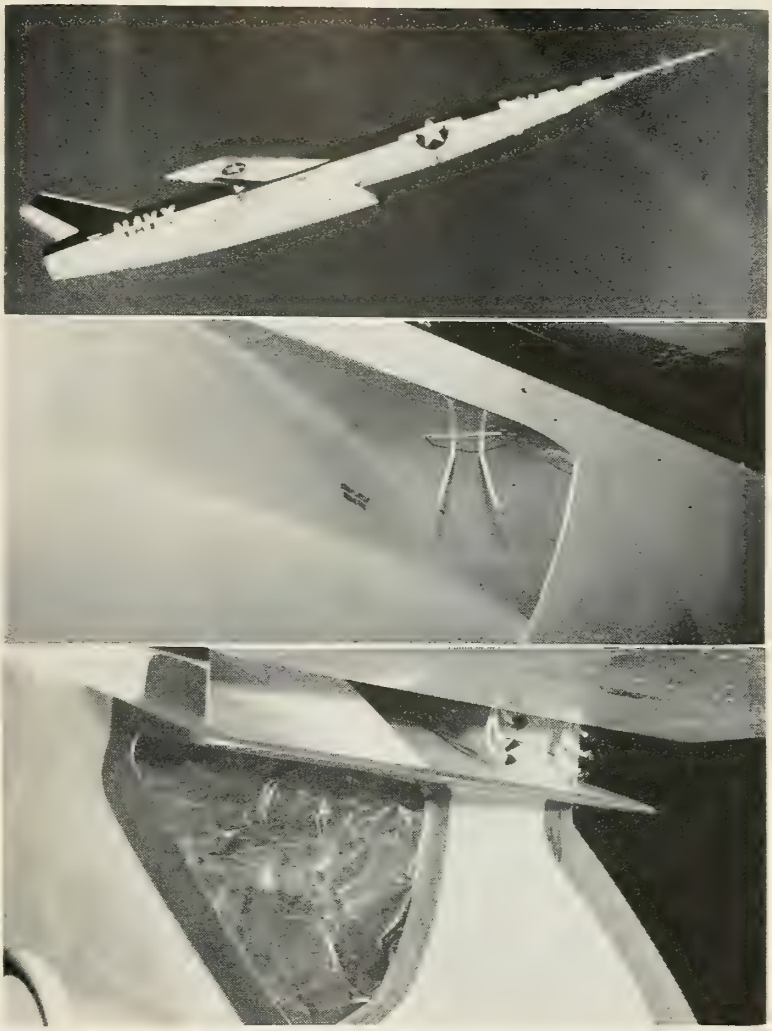
Also, like its predecessor, *Regulus II* carries a nuclear warhead, either fission or fusion. It has already flown over 50,000 feet and has an all-weather range of over 500 miles. As of March 1, there had been thirteen *Regulus II* flights—six with the same missile.

While *Regulus II* was making its first public appearance, it was announced that *Regulus I* had successfully completed more than 500 flights. Also, it was reported that *Regulus I* was now being tested under near-Arctic operational conditions in the North Atlantic. In addition to being able to perform its mission from either land, surface ship or submarine, the *Regulus I* has been developed into a highly successful target drone.

Regulus II's production power plant will be the General Electric J-79 with full afterburner.

This engine is currently rated at 12,000 pounds dry thrust and 16,000 wet, which should make *Regulus II* nearly hypersonic in its final dive.

There are reliable reports that the effective range of the *Regulus* missile series may be increased to as much as 1,000 miles by the addition of podded fuel tanks.



Trainer-test version of Regulus utilizes boundary layer to enable it to make wheeled landings for full recovery. Designed as a one-way missile, it has virtually no low-speed aerodynamic characteristics, landing at 250 knots. Middle picture shows boundary layer exhaust duct. Bottom shows in-take just over main engine intake.

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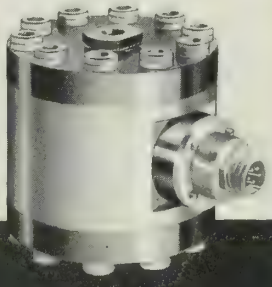
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Rocket Trends

By Erik Bergaust

Convair did an outstanding job on its space flight symposium co-sponsored by AFOSR in San Diego last month. This is the kind of thing the American Rocket Society should have undertaken long ago. "We ought to have these symposiums at least once a year," AFOSR Brig. Gen. Hollingsworth Gregory told this writer. The symposium was attended by more than 500 engineers and scientists. It was the first of its kind, and it was successful, indeed. Congratulations to Convair's Dick Gottschall and the entire PR staff for the fine way they handled press relations; they went all out to help newsmen get the right kind of story across to the public about these highly scientific subjects. Several companies said they would consider taking on next year's symposium. By the way, the first symposium was a punchy inauguration for the Air Force in its *psychology campaign* for justification of the forthcoming space flight programs.

Lockheed is pushing the X-17 real hard. During our quick tour of the Los Angeles missile boom area, we were told the X-17 is "a most successful test vehicle." In fact, we learned reliably that Lockheed has proposed a new *weapons system based on the X-17*. The monster can zoom to 300 miles straight up if desired. However, the three-stage missile is designed to topple over. Re-entry then becomes a *powered downward flight* of Mach 15 velocity. Lockheed's missile group has several missile proposals in the works. Among others, the company is understood to have prepared a couple of space flight proposals. The Air Force reconnaissance satellite remains a mystery, and Lockheed officials cannot say a thing about it. Said one AF official: "That kind of satellite will become part of a gigantic future weapons system." Other than the fact that the reconnaissance satellite is being planned, the project is hush-hush.

Northrop is justifiably proud of its Mark I guidance system for the *Snark*. Within security limits this reporter was given the opportunity to watch the production phase of the all-Northrop inertial system. *Snark* production—in general—is getting underway at an accelerated rate, indicating General Curtis LeMay wants his long-range missiles as soon as possible. (He could have had them two years ago if the Air Force had been somewhat more enthusiastic in carrying out its long-range missile program.) Northrop can't tell you how many successful *Snark* flights they've logged, but they are numerous. Of course, you don't hear about the successful ones . . . Northrop also showed this writer a new 7-minute *Snark* movie—quite spectacular —that will be made available soon to interested groups. Company officials couldn't confirm that Northrop is working on a super-duper missile. But one Northrop scientist said: "We would be off our rocker if we weren't looking ahead for new challenges."

Grand Central Rocket will hire another 100 engineers this year. Expansion is in full swing and *Dart* powerplant production (plus two classified missiles) is in the undertaking. A low-and-slow sightseeing trip by light plane over the company's newly acquired 8,000 acre test site in the remote Riverside County area revealed a million-pound thrust cell—the first of many. Says technical director Frank Marion: "We will compete with the liquid boys soon—*20% more specific impulse and 5% better density is what we need.* And we're working hard to achieve it. We'll do it." The company has all kinds of projects in the mill and are submitting frequent proposals. *Vanguard* third-stage engine tests are routine now, numerous successful firings having been conducted. Grand Central's Bob White will be out killing rattlesnakes again this spring, because the company's noisy engine tests fail to scare the diamondbacks away.



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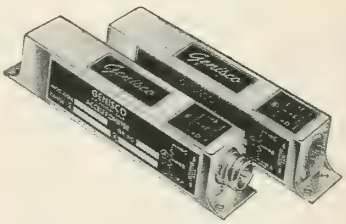
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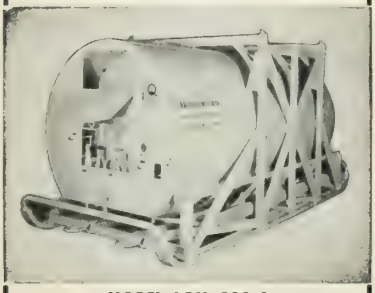
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Washington Spotlight

By Henry T. Simmons

The precarious future of the *Navaho* intercontinental missile is dramatically illustrated by the fact that there are no funds for its support in the fiscal 1958 Air Force budget. The program was almost wiped out during preparation of the new budget, but was saved through some financial leger-de-main with fiscal 1957 funds. The project was re-oriented along purely research lines and a number of XSM-64 test *Navahos* were lopped off. USAF will decide in fiscal 1958 whether the project will get full support or die a quick death. Cutback forced North American to lay off 300 *Navaho* workers and re-assign another 300, but it still hopes to finish tests of the ramjet-powered prototype on schedule.

•

This view of the cutback may sound like rank optimism, but it rests on some important considerations. The XSM-64, for example, is equipped with landing gear and is theoretically recoverable with a dead-stick landing procedure developed on its predecessor, the turbine-powered X-10. Judging from the good results with the X-10 (Number One was fired 11 times before plunging into the sea), a smaller number of "X" *Navahos* will suffice for the test program. Perhaps more important, the SM-64A production version now in the design stage incorporates so many improvements over the test model that the original elaborate program is no longer deemed necessary.

•

Attempts to launch the XSM-64 got under way at Patrick AFB, Fla., late last year, but as this is written, the Air Force is still looking for its first successful firing. The initial try in December came to grief when the huge missile reached 9,000 feet; a rate control gyro malfunctioned and the test was aborted. Later efforts were plagued with range difficulties. On one occasion, a freighter wandered into the booster dump zone off Cape Canaveral; by the time the count-down could be resumed, a down-range tracking station broke down and the test had to be canceled. Although these troubles suggest the *Navaho* will prove at least as cantankerous to develop as any other advanced weapon system, its supporters insist that the new bob-tailed program still allows for such setbacks.

•

Latest explanation of the testing troubles of another Air Force missile, the *Thor,* blames the January launching stand explosion on foreign matter which was allowed to contaminate the fuel. If so, the hardware of the IRBM—including the North American engine—is absolved of guilt in connection with the mishap.

•

Future Navy interceptors may carry mixed loads of missiles—one radar *Sparrow* and one infra-red *Sidewinder.* Latter weapon is immune to countermeasures, but can't be used in rain or heavy clouds while the former is an all-weather weapon. Hughes is developing an infra-red *Falcon,* indicating USAF may follow this approach.

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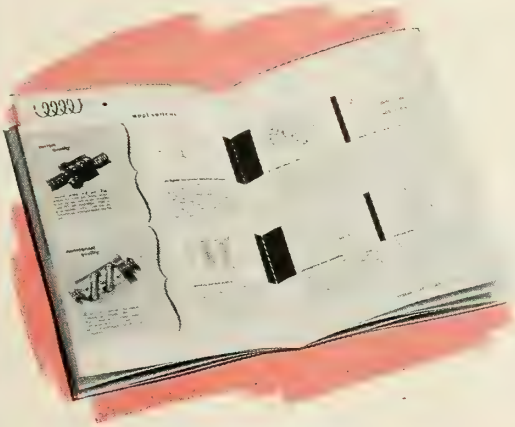
The new air-to-air rocket with the nuclear warhead which Defense Secretary Charles Wilson announced last month is the Douglas *MB-1,* a liquid-propellant missile now in operation with the Air Defense Command. It used to be called the *Ding Dong,* but disgruntled USAF security officers changed it to *High Card* when it leaked out. The second name also leaked, so the weapon was given its present inglorious moniker. The Northrop F-89J and the Convair F-102 and F-106 will carry the new weapon, later versions of which will use a solid-propellant motor.



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Research and development at Lockheed Missile Systems Division laboratories in Palo Alto is of a most advanced nature. Particular areas of interest include microwaves, telemetering, radar, guidance, reliability, data processing, electronic systems, instrumentation, servomechanisms. Inquiries are invited from those qualified by ability and experience for exploratory efforts of utmost importance.

Here members of the Electronics Division discuss systems radar problems related to measurement of missile trajectories. Left to right: K. T. Larkin, radar and command guidance; Dr. S. B. Batdorf, head of the Electronics Division; Dr. H. N. Leifer (standing), solid state; Dr. R. J. Burke, telemetering; S. Janken, product engineering.

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MARCH, 1957

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m/r exclusive:

1957 Research Rocket Roundup

The first sustained use of the rocket vehicle for upper atmosphere research followed the close of World War II, when some 100 of these rockets were brought over to the U.S. At that time V-2's were available in considerable quantity. By early 1946 the Upper Atmosphere Research Panel had been established. The name was changed in 1948 to the Upper Atmosphere Rocket Research Panel. Its members included top scientists concerned with upper air research from Evans Signal Laboratory, Naval Research Laboratory, Air Force Cambridge Research Center, etc., as well as universities, observatories, and private companies.

U.S. scientists and military firing crews launched the first V-2 in the U.S. on April 16, 1946. On June 28 the first completely instrumented, high-altitude research V-2 took off from the White Sands Proving Grounds. One was launched from the U.S. aircraft carrier Midway in late 1947.

General Electric Co.'s Project Hermes fired the most research V-2's, gaining great experience from the German scientists who worked in this country after the war and from translated German reports. Army Ordnance was the cognizant military agency.

Standard and Modified V-2's

The standard V-2 warhead had about 16 cubic feet of space available for instrumentation. In a number of V-2's redesigned by the USAF, instrumentation space was increased to 80 cubic feet, increasing the rocket length about five feet, increasing the length from 524 to 589 inches. However, the V-2 still had disadvantages. It was an old missile. Many parts were unreliable and had to be rebuilt. It was much too big. For stability reasons, its full one-ton payload had to be carried, and because a ton of instruments cannot be crammed into such a small space, useless ballast had to be added.

In general, the use of military missiles for research is not particularly attractive. But the V-2 was available, and it launched a very important and sustained U.S. research program.

Of the 70 odd V-2 firings undertaken by the U.S. about 75% were considered successful, meaning they hit altitudes of 50 miles or more.

Staging Sets Record

An important step in the program was the mating of the V-2 with a small American WAC-*Corporal*. A series of these *Bumpers* were fired, including one that broke all altitude records and another that broke the atmospheric velocity record. Most of them were fired from White Sands Proving Ground, but two were launched from the Patrick Air Force Base Missile Test Center in Florida in an attempt to gain maximum range and velocity. The fifth *Bumper* rocket, fired from New Mexico, hit over 5,000 miles per hour, and the small WAC-*Corporal* reached a peak top altitude of 244 miles. This world's record was only recently broken by a three-stage rocket using a *Redstone* missile as the first stage and modified *Sergeants* (or *Recruits)* as second and third stages. These early *Bumper* flights taught scientists how to: communicate beyond the ionosphere; work with staging problems; ignite motors at extreme altitudes.

By July 1, 1951 Project Hermes ended, a success. Under Hermes, the peak altitude gained was 116 miles. There were also a number of test firings made by White Sands personnel and other agencies. One of these, an uninstrumented rocket launched in late October, 1951, reached 132.5 miles.

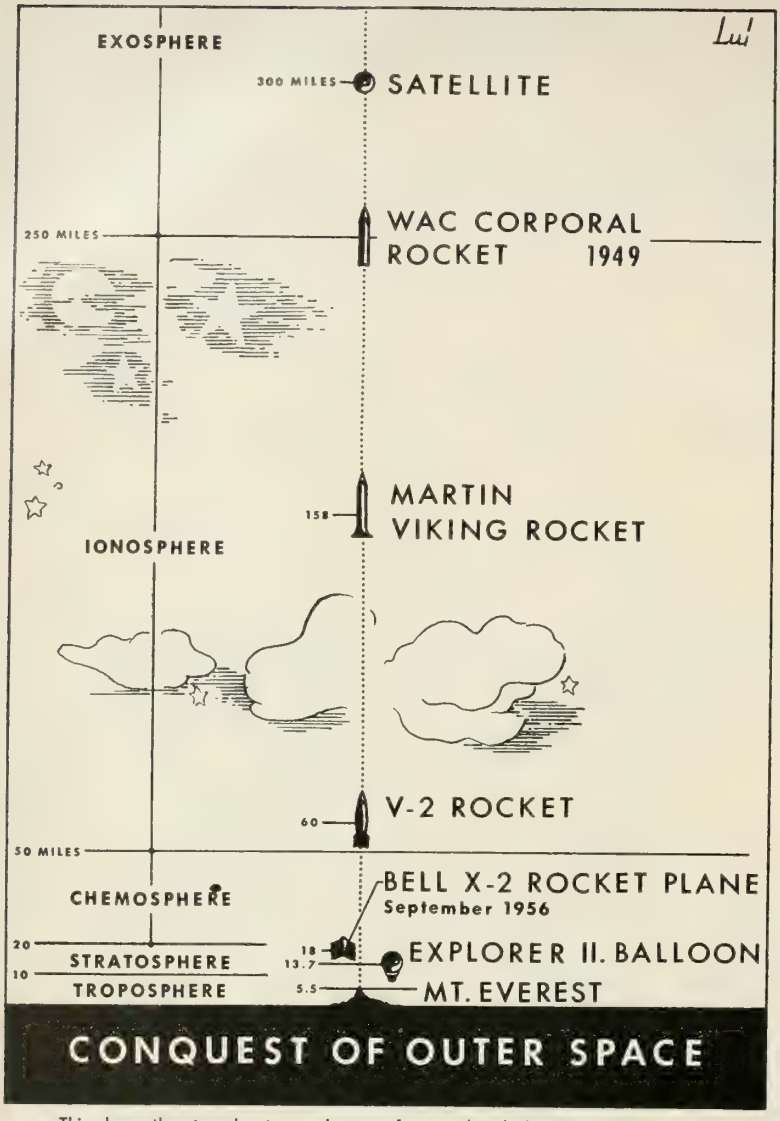
m/r presents herewith what it believes to be the most complete roundup of the history and specifications of research rockets ever compiled at one time. The research rocket is a peaceful vehicle. The data it gathers pioneers man's approach to outer space. Frederick I. Ordway III and Ronald C. Wakeford, who are to be congratulated for authoring this roundup, are President and Research Engineer, respectively, of General Astronautics Corp.

America Makes Its Own Rockets

About 1930 the Daniel Guggenheim Foundation provided Dr. Robert H. Goddard with the grant that gave U.S. rocket research its start. At California Institute of Technology's Guggenheim Aeronautical Foundation, a group of rocket researchers worked into the late 1930's. At the same time, on the east coast, the American Rocket Society was performing its research work and later a group of experimenters at the U.S. Naval Academy also did rocket research.

During the war at Cal. Tech's Jet Propulsion Laboratory the first sustained government supported rocket research began. This led directly to the development of research rockets. One of the first steps was the *Private A* rocket and later the *Private F*. These small, fixed-finned rockets were launched from steel booms about 36 ft. long, ascending on four guide rails and were boosted during their travel in the small steel guide booms. Many tests were made during 1944-45 at Barstow, California, and later at Ft. Bliss in Texas.

The group that designed and developed these rockets was called ORDCIT—Ordnance Contract to the California Institute of Technology. They were asked to develop a sounding



This shows the stage-by-stage advance of research vehicles towards free space. The JUPITER-C, of course, with a record altitude of 680 miles, is off the chart.

rocket to carry a small 25 pound payload up to, perhaps, 20 miles. They built the *Baby*-WAC, which was test fired during July, 1945, at the California Goldstone Range. It was a one-fifth scale model of the 16 foot long, 665 pound WAC-*Corporal* that was later developed from it.

The first firing of the WAC-*Corporal* was on September 26, 1945, at the White Sands Proving Grounds, some six months before the first V-2 launching in the U.S.

Aerobees and Aerobee-Hi's

While the V-2 was too big, the WAC-*Corporal* was too small for many research purposes. This led to the first specifically designed upper air research vehicle, the *Aerobee*, developed by the Applied Physics Laboratory of Johns Hopkins University and the Aerojet Engineering Corp.

Most of these *Aerobees* have been built by the Douglas Aircraft Co. The first *Aerobee* contract was let in 1946 by the Navy Bureau of Ordnance in close cooperation with the Office of Naval Research. The preliminary order for 20 was later considerably increased.

Other services, such as USAF, have also ordered *Aerobees*. The first full firing occurred (dummy missiles had been booster-launched earlier) in November of 1947. By 1948 an *Aerobee* had reached 70 miles, and somewhat later another soared 100 miles. Like the V-2, they also have been launched from shipboard.

A variation of the *Aerobee*, the *Aerobee-Hi*, was developed and by 1955 it reached 124 miles. Later, the world's single-stage altitude record was broken by a 164 mile flight.

Aerobees have been used by all services and are most versatile and successful. Up to last summer some 150 had been launched, with 128 operationally successful. They were fired as follows: Johns Hopkins University, 17; U.S. Army Signal Corps, 33; U.S. Navy, 35; U.S. Air Force, 65.

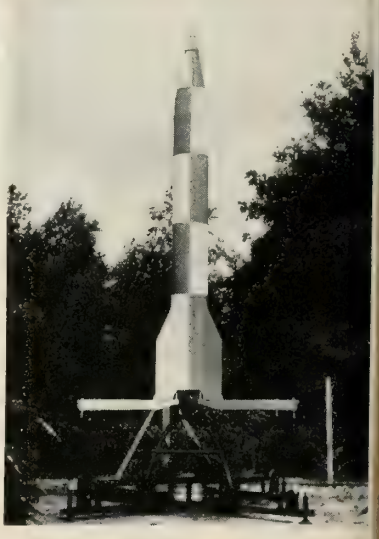
More than 50 *Aerobees* will be fired from Ft. Churchill and Holloman during the International Geophysical Year. Experiments will include free-electron density studies, ultra-violet radiation, cosmic ray, Lyman-alpha and day brightness investigations, and research on the existence and density of interplanetary matter to 200 miles.

Air Force Program

In 1952 the Air Force negotiated a contract with Aerojet to improve the *Aerobee*. Two basic improvements were made: 1) The propellant tanks were enlarged to handle 32 per cent more fuel and oxidizer; and 2) these tanks were made of lighter 410 stainless steel. This improved the mass ratio from 3.17 to 4.62. On its first flight in April, 1955, with a payload of 196 pounds, it soared to 124 miles.

Navy Program

Because of a desire to get into the F region of the ionosphere the Navy program called for the thrust chamber as well as the overall rocket to be completely pressure-sealed. This would eliminate the danger of escaping gas



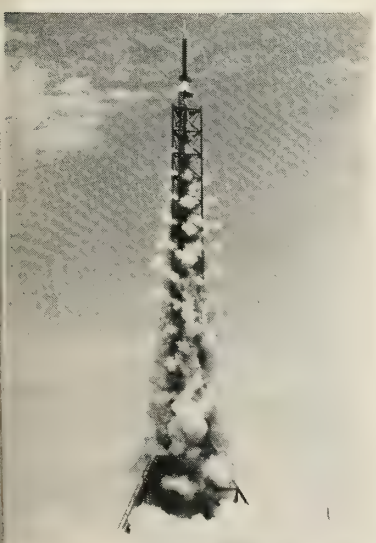
Veronique, star of France's missile effort, was developed under the Ministry of Defense. The vehicle hits 3200 mph, carries 133 lb. payload.

from contaminating the ambient conditions and thereby invalidating upper air experiments. Not only did the Navy use the AF's improved steel tank material but it further increased the propellant capacity of the vehicle, improved the thrust chamber assembly, and of course, the mass ratio. A chemical gas generator replaced the helium tank.

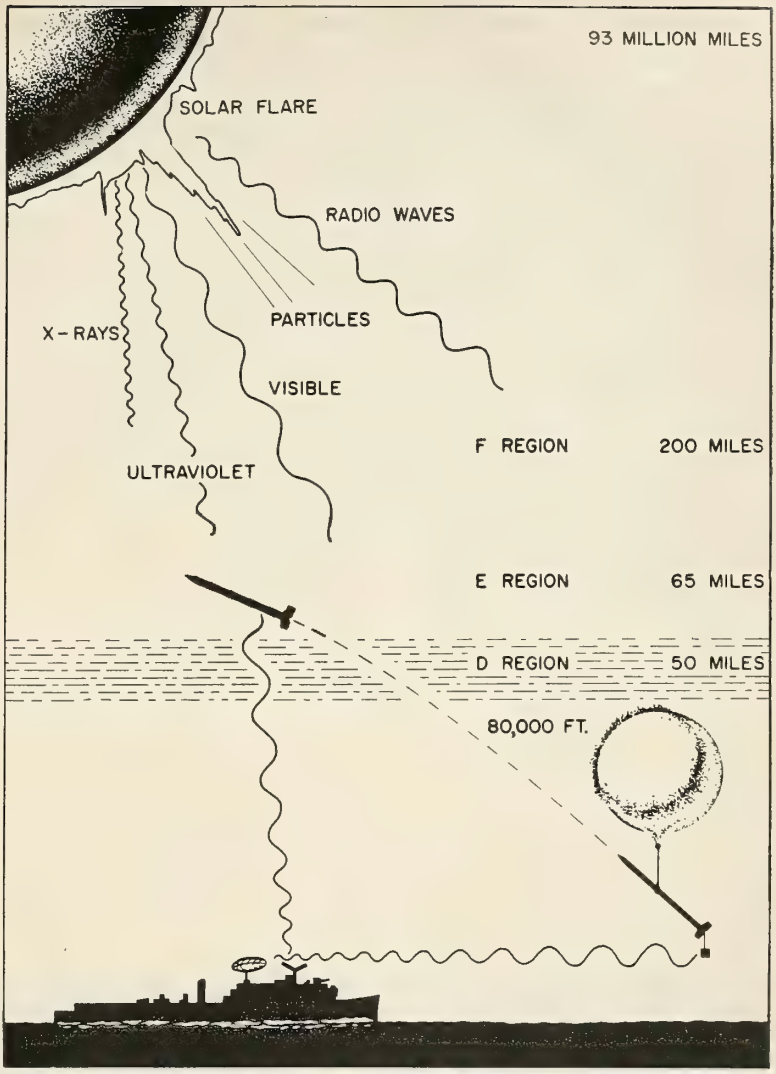
Due to the lack of time and the urgencies of the IGY, the development efforts of the chemical pressurization system will be suspended, and Navy *Aerobee-Hi* rockets will use helium pressurization techniques during the next few years. However, a better acid appears to be on the way as well as an uncooled combustion chamber.

The basic aim of this program is to reach 180 miles with a 150 pound payload. In pre-IGY tests at Fort Churchill, Canada, additional RT-N-13B's were successfully fired, as well as a RV-N-13C which carried 156 pounds to 157 miles. The Air Force Model AJ-11-6 carries a 150 pound payload to about 140 miles, and, due to different launching conditions, to 165 miles at White Sands Proving Ground. The Navy RV-N-13B carries its 150 pound payload to 147 miles; to 162 miles if launched from White Sands. If the payload is lowered to 120 pounds both these missiles should gain another 17 miles under sea level launch conditions and an Arctic atmosphere.

According to Townsend (in an American Rocket Society Annual Meeting lecture), when the Navy *Aerobee* changes its tanks to the new type it should gain another 10 miles. Eventually both the Air Force and the Navy



The 4,435 mph AEROBEE-HI shoots from its launcher at White Sands Proving Ground, N. M. is used for ionosphere research.



Artist's sketch of ROCKOON, 68-foot diameter plastic balloon and a 12-foot solid propellant DEACON sounding rocket at they will perform during the IGY.

models will probably use a ceramic lined thrust chamber (such a chamber is now under development, to deliver 5,000 pounds of thrust). A Navy *Aerobee-Hi* should reach 167 miles with a 150 pound payload under Arctic atmosphere and sea level launch conditions. If this chamber is used with a 120 pound payload, a 188 miles altitude would be possible and if fired at White Sands, an additional 15 miles.

Vikings Replace V-2's

Going back to 1946, and picking up the thread from the East Coast companies, we find the *Viking* program underway. At NRL plans had been hatching for some time to develop and build a fairly large U.S. rocket vehicle capable of replacing V-2. It was apparent that the supply of V-2's in the United States would not last forever and that if the U.S. wanted large rocket missiles when this supply was exhausted, it would have to begin work immediately. NRL contracted with the Glenn L. Martin Co. in August, 1946, for 10 large rocket vehicles. Later this was upped by four additional missiles. The powerplant award contract went to Reaction Motors, Inc., organized in 1941 by a group of American Rocket Society experimenters. First called the *Neptune,* the name was changed to the *Viking* so as not to confuse it with the Navy *Neptune* airplane. Until recently the 158 mile altitude reached by a *Viking* was the world's record.

Vikings have undergone continued change during the overall development program. The first seven were relatively similar, as are the latter series. For example, the earlier *Vikings* were more

than 48 feet high; the later *Vikings* were less than 42 feet. This can be compared with the 46 foot V-2. The first series were only 2 feet, 8 inches in diameter, the second series nearly 4 feet. Compared with the nearly 5½ foot V-2 rocket, both missiles are slim. The thrust generated by the *Viking* rockets ranges from 20,000 to 21,500 pounds, compared to the 56,000 to 60,000 pounds of the V-2. The rockets weighed anywhere from a little under 10,000 to a little under 16,000 pounds, which again compares with the much heavier German vehicle.

Some element of success attended all the *Viking* firings with the exception of No. 8, which broke away in a static test.

The payload of missiles has changed a lot in recent years. Formerly, it was common to carry on a fairly wide variety of experiments from one vehicle having payloads of many hundreds of pounds. Today it is amazing what can be done with relatively low (25 to 50 pound) payloads. The tendency now is to use a given rocket for a given experiment. For one thing altitudes will vary depending on the experiment. Some experiments should be made near the peak of the rocket trajectory. Others can be profitably made on the upward trajectory or on the downward trajectory. If too many different experiments are made with a given rocket, damage to some of the other experiments may occur, and consequently, we find that the general philosophy of one rocket for one experiment (or at least very few experiments) is gaining favor.

While most vehicles are being fired in a vertical or near vertical trajectory, attitude control is not always necessary. Some vehicles have to have this attitude control for certain experiments such as following the sun. Others that might want to go into a special trajectory (such as the *Vanguard* rocket when it launches the Earth satellite) require spin stabilization, and so forth.

As with the *Aerobee* rocket, the problem of contamination is very important in making atmosphere composition experiments. For example, if exuding gases from the rocket are allowed to enter the atmosphere and contaminate the sampling bottles, accurate chemical analysis is impossible. For that reason clean rockets are needed.

The recovery of data is, of course, extremely important. Biological specimens, photographs, etc., have to be directly recovered by some sort of a drogue or parachute technique, or by aerodynamic descent following separation of the nose cone from the vehicle.

It is one of the characteristics of the 1950's that all too little money is available for upper air rocket research; so it is all the more important the price be kept as low as possible. An *Aerobee*, for example, costs between $30,000 to $40,000 per rocket, somewhat less than the *Viking*. *Deacon* and *Cajun* rockets are less expensive than the *Aerobee*, a great advantage to the private companies and universities that may want to fire them. In addition to the rocket other costs include logistics, instruments, personnel, etc.

In a recent American Rocket Society paper on future sounding rockets, the *Spaerobee* was introduced, which adds a second stage to an *Aerobee* to give an altitude capability of about 350 miles. The payload would be 40 pounds. A second new vehicle is the *Aerosound* which is launched from an airplane in a vertical attitude. It would carry 40-pound payloads to perhaps 45 miles or 20 pounds to 54 miles. A two-stage *Aerosound* would fly to over 100 miles with identical payload weights.

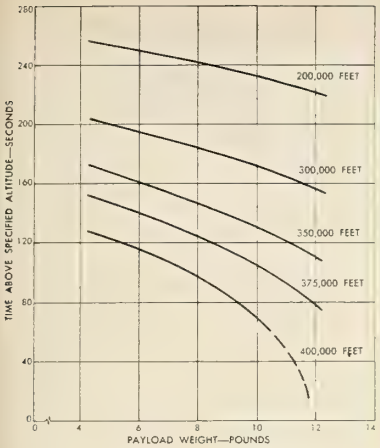
U.S. Research Rockets — The Finer Details

Consistent with observations of changing techniques in rocket research, we find a whole new crop of small, efficient vehicles entering the pre-IGY scene. They carry such names as *Rockoon*, *Rockaire*, *DAN*, *Nike-Cajun*, *Terrapin*, *Asp*, and *Wasp* and generally cost only small fractions of *Viking* and *Areobee* rockets. Capsule information is presented on these vehicles in so far as it is now available.

One of the factors that led to the *Nike-Cajun* combination was that the *Rockoon* rocket was hard to track to



Rocket's eye view from about 100 miles up. The Navy believes this to be the largest earth area ever photographed from one spot.



Time that Terrapin remains above specified altitude for vertical launch.

its point of impact. This was because the exact time of discharge from the balloon could not always be told, nor could the precise location of the balloon be known because of drift. In 1954 work started on providing the *Deacon* with a *Nike* booster. The aim was to bring 50 pounds up to about 75 miles. A coasting period between the exhaustion of stage one and the firing of stage two was planned. Result was the *Cajun* rocket little more than a *Deacon* with an improved solid-propellant charge. Army Ordnance supplied boosters, and instrumentation was provided by those agencies carrying out the experiments. Successful tests were made during the fall at Fort Churchill, Canada, one of which carried 100 pounds up to 70 miles.

Weight, pounds 1,550
Wt. of *Cajun,* loaded, pounds ...250
Length, booster & rocket feet . . . 26
Coasting period (between separation of the rockets and firing of the top stage), seconds ..... 10 to 20
Number of *Nike-Cajuns* to be fired during IGY . . . 65 (42 will be fired from Churchill, and the rest from ships, at Guam, or at White Sands).
Record altitude for a *Nike-Cajun* . . . 95 miles (flight by the Ballistic Research Laboratories on 9 Aug. 1956. Payload was 60 pounds).
Cost . . . $4,000 (not including instruments, the booster costs an additional $3,700).

Recently four fairly successful firings of these rockets have been made. Scientists had hoped for somewhat higher altitudes than obtained.

DAN

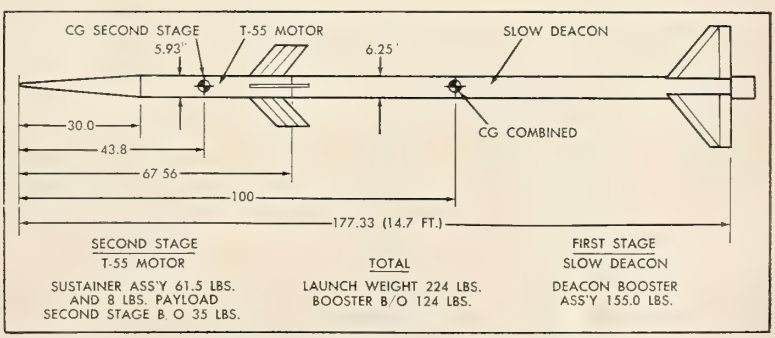
If an unimproved *Deacon* is used, we have what is known as the *DAN* (*Deacon* and *Nike*). This program was initiated by NACA. It is obvious that



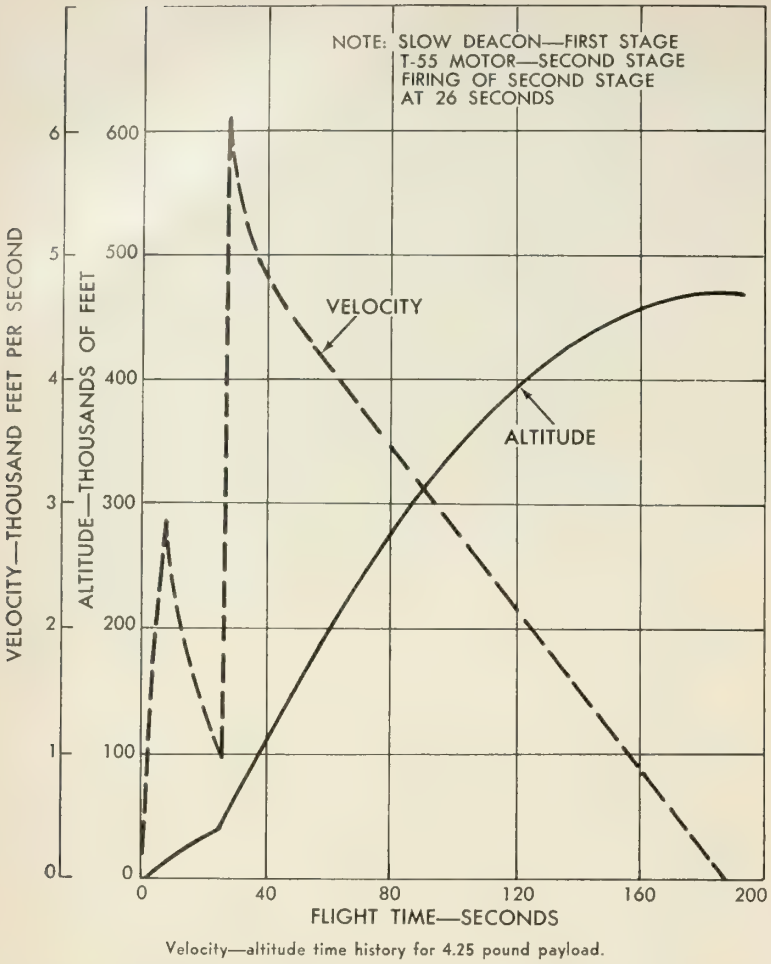
Artist's conception of an IGY satellite over a Minitrack ground station antenna array.

DAN and *Nike-Cajun* are essentially the same thing. A few figures quoted for DAN appear below:
Contractor ... NACA and U. of Mich.
Cognizant agency .....U.S.A.F., Cambridge Research Center.
Weight, booster, pounds 1,324
Weight, second stage, pounds . . . 216
Payload, pounds 10-60
Altitude, miles 70-95
Altitude, separation, feet . . . approximately 5,000
Velocity, maximum . . . . . Mach 5
Instrumentation .....Free-fall accelerometer sphere (air density measurements).

DAN has recently been replaced by the *Nike-Cajun.*



TERRAPIN Two-stage high-altitude research rocket developed by Republic Aviation Corp.



Velocity—altitude time history for 4.25 pound payload.

IRIS and ARCON

Two of the newer basic research rockets currently sponsored by the Navy are the *Iris* and *Arcon*. Both are being developed by Atlantic Research Corp. of Alexandria, Virginia. Details of the design specification indicate that the vehicles are propelled by solid fuel motors. The *Iris* rocket will have a burning time of 40 seconds and will undertake upper atmosphere experiments similar to those of the *Aerobee-Hi* (probably eventually replacing it). Preliminary information indicates that neither *Iris* nor *Arcon* will be boosted. It is expected that *Iris*, a fin stabilized vehicle, will be launched during the latter half of 1957 or early in 1958. *Arcon*, a somewhat simpler vehicle to produce, and further along than the *Iris*, is almost sure to be fired in 1957.

Data	Iris	Arcon
Diameter, inches	12	6
Length, overall, feet ..	14.83	11
Weight, pounds 1,000		250
Payload, pounds	100	40
Altitude, miles	200	70

TABLE NO. 1

VIKING SERIES

Viking No.	Launch Date	Altitude (Miles)	Payload (Pounds)
1	3 May 1949	50	464
2	6 Sept. 1949	32	412
3	9 Feb. 1950	50	528
4	11 May 1950	105	959
5	21 Nov. 1950	108	675
6	11 Dec. 1950	40	373
7	7 Aug. 1951	136	394
8	6 June 1952	4	
9	15 Dec. 1952	135	765
10	7 May 1954	136	830
11	24 May 1954	158	825
12	4 Feb. 1955	144	887
13	8 Dec. 1956	125	

TABLE NO. 2

Time Viking Rocket No. 7 spends above:

Kilometers	Seconds
30	400
40	385
100	315
120	200

TERRAPIN Rocket

Another in a series of small, solid propellant rockets, the *Terrapin*, was first flown late last year at NACA's Wallops Island facility. So far it has been used to make cosmic ray, temperature and rocket spin and acceleration measurements. Instrumentation includes all transistorized telemetering equipment, geiger counter and transmitter. It will be used for sustained upper atmosphere research in the 80 mile region. Several dozen rockets will probably be produced.

Contractor...Republic Aviation Corp.

Cognizant agency .....Navy Bureau of Ordnance via U. of Md.

First stage motor contractor . . . Alleghany Ballistics Laboratory—Navy Bureau of Ordnance.

Second stage motor contractor . . . Thikol Corp. with the Redstone Division of the Army Ordnance.

Vehicle type .....Two-stage

Launcher . . . Collapsible zero length

Weight, overall, pounds 224

Instrumentation, pounds 6

Length, approximate, feet 15

Diameter, inches 6¼

Velocity, maximum, mph 3,800

Time to impact, minutes 5.6

Altitude (first flight), miles 80

Temperature (skin), max, °F . . 1,000

Propellant .....Solid

Operational sequence: The solid propellant first stage engine carries the *Terrapin* to nearly two miles in six seconds. (Speed: 1,900 miles an hour). Then the first stage separates from the second stage, which coasts to about 7½ miles. The second stage motor now fires, bringing the missile to 9½ miles at a speed of Mach 5.8 (3,800 miles an hour). It coasts to peak.

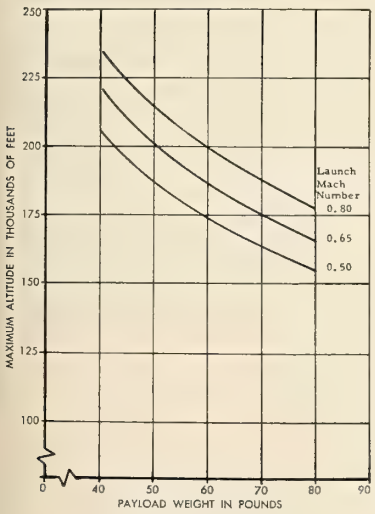
ROCKOON Missiles

The *Rockoon* system of high altitude research, begun in 1954, was the result of the Naval Research Laboratory's efforts to obtain basic data from high altitude at less cost than was possible with larger rocket vehicles.

The configuration consists of a *Deacon* rocket suspended from a 68 foot diameter plastic balloon (Skyhook). At 15 miles altitude the rocket is fired into the lower ionosphere. In July of 1956 ten such arrangements were launched to obtain information on solar flare activities. These balloon/-*Deacon* firings were supervised by Dr. H. Friedman of NRL Optics Division.

Contractor . . . Douglas Aircraft Co.
Powerplant manufacturer . . . Allegany Ballistics Laboratory.
Cognizant agency . . . U.S. Navy via State U. of Ia.
Length, feet 12.3
Diameter, inches 6.6
Weight, loaded, pounds 218
Weight, payload 20-30
Thrust, pounds 5,700-6,000
Propellant .....Solid
Altitude, miles 50-70
Guidance .....Fin stabilized
Firing time, seconds 3-3½

ROCKAIRE Missile



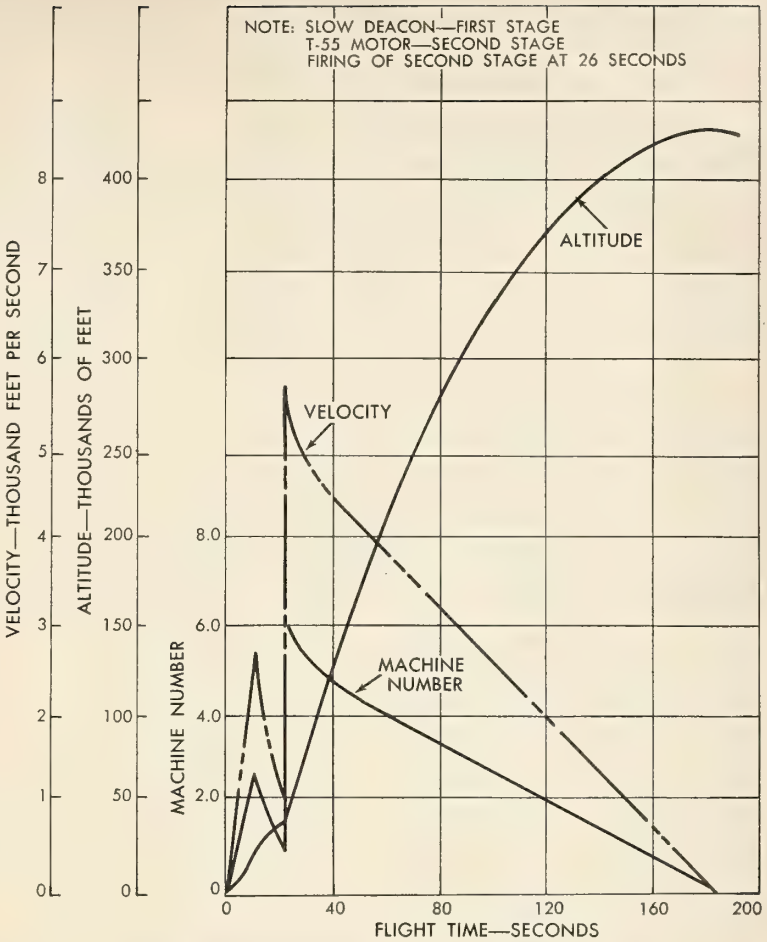
ROCKAIRE

This program was born of the desire to fire rocket missiles in areas other than where established large launching areas are located. The small rocket has drawbacks, particularly in its altitude capability. For example, a *Deacon* rocket could hardly get any higher than a balloon if launched from the surface. So these small rockets either have to be boosted or launched by balloon or aircraft. This *Rockaire* combination is a *Deacon* launched from an aircraft in an almost vertical attitude, for maximum height attainment. According to Air Force Cambridge Research Center's R. M. Slavin, a 40-pound payload *Deacon* gains 7,000 feet in zenith altitude for each 1,000 foot increase in launch altitude.

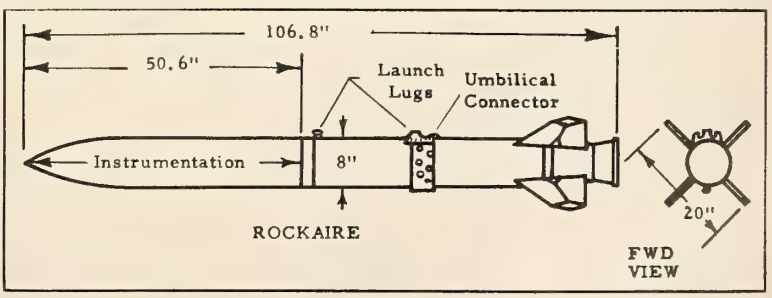
Principal contractor . . . . . Douglas Aircraft Company.
Typical launching technique . . . At 6 or 7 miles altitude an F-86 airplane assumes a near vertical attitude and launches the rocket.

Launching area . . . Holloman Air Development Center.

Tracking . . . The rockets will be tracked from ground stations. (Later a C-131B aircraft will carry the tracking devices as well as telemetry receiving devices).
Altitude, max. expected, miles . . . 100



Velocity—altitude—mach number time history for 8.25 pound payload.



Schematic of the ROCKAIRE research rocket.

TABLE NO. 3

COMPARISON TABLE—Vikings 7 and 9, and V-2

Item	Viking 7	Viking 9	V-2 (U.S. adapted)
Length, feet	48.75	42	46.5
Diameter, feet	2.66	3.75	5.42
Payload, pounds	394	825	2500 (average)
Burning time, seconds	72	103	68 (typical)
Time to peak, seconds	266	309	220 (average)
Thrust, pounds	21,080	21,400	56,000
Weight, overall, pounds	10,730	15,005	28,300-29,000
Velocity, mph.	4,000	4,300	3600
Altitude, peak, miles	136	158	132 (Flight TF-1)
Acceleration, g (maximum)	7	8	6.6 (Typical)

TABLE NO. 4

WAC-CORPORAL

	Rocket	Booster
Length, feet	6	5
Diameter, inches	12	12
Weight, loaded, pounds	665	546
Weight, payload, pounds	25	
Altitude, without booster, miles	19	
Altitude, with booster, miles	45	
Velocity, mph.	2,800	1,700
Thrust, pounds	1,500	50,000
Propellants	nitric acid/aniline	solid
Specific impulse, seconds	195	202
Firing time, seconds	45	0.6

Navy ROCKAIRE

Meanwhile, the Navy has been working on a *Rockaire* system for high altitude investigations. Instead of employing *Deacon* rockets, it has taken both the standard 2.75 inch aircraft rocket and the 5 inch HVAR and adapted them so that they could be near-vertically launched from F2H-2 fighters. One cosmic ray instrumented 2.75 inch *Rockaire* soared to a peak altitude of 34 miles. When instrumented, the nose cone is lengthened slightly by half an inch.

ROCKAIRE X113C4 Motor

Thrust .....7,800 lbs.
Burning time .....2.15 secs (60°F)
Total thrust .....15,000 lb-sec
Propellant wt .....70.3 lb.
Specific impulse .....210 sec
Launch weight (inc. 40 lb. p. l.) . . . 181.4 lbs.

2.75 Inch Rocket Data:

Cost $50.00
Length, feet 4
Diameter, inches 2¾

TABLE NO. 5

PRIVATE A*

Length, feet	8
Weight, loaded, pounds	500
Weight, payload, pounds	60
Range, miles	> 11
Thrust, pounds	1,000
Thrust, booster, pounds	21,000
Firing time, seconds (sustainer)	30

*Private F was a slightly modified model with trimmers at nose, five foot span.

TABLE NO. 6

RECORD BUMPER FLIGHT

Flight No.	5
Date	Feb. 5, 1949
Loaded weight, pounds	
First stage	28,297
Second stage	621
Velocity, m.p.h.	
First stage	2,615
Second stage	5,150
Altitude, miles	
First stage	63
Second stage	244

Weight, pounds 18.1
Weight, head, pounds 6.5

Firing Data:

Average firing altitude, miles 5½
Average airplane speed, knots 215
Aver. airplane climb angle, degrees 86
Flight time, minutes 3½
Period above 100,000 feet, seconds . . . 120-140

Possible Experiments:

Cosmic ray
Solar ultra-violet
Atmospheric composition
Temperatures and winds

The ASP Missile

Asp (Atmospheric Sounding Project) is employed in making meteorological, cosmic ray, and geomagnetic experiments in the upper atmosphere. Due to its high velocity it may eventually be used in hypersonic testing.

Contractor Cooper Development Corp.
Powerplant contractor . . . . . Grand Central Rocket Co.
Cognizant agency . . . Bureau of Ships, U. S. Navy (contract NObs-72000).
Program .....Operation Redwing
Length, overall, feet 144
Diameter, inches 6.5
Span, inches 20
Launching weight, pounds 245
Empty weight, pounds 95
Payload, pounds 25
Summit altitude, miles 40
Burnout velocity, mph. .....3,700-3,900 (depending on launch location).
Firing time, seconds 6
Thrust, average, pounds 5,850
Specific impulse, seconds 211
Impulse to motor weight ratio 162
Initial launch angle, degrees 30
Propellant . . . Solid 201-C (amonium perchlorate-polysulfide, rubber type).
Telemetering head . . . Consist of. a) antenna, b) insulator, c) ogive, d) thermal barrier, e) telemetering and instrumentation mounting structure.
Antenna . . . Quarter wave spike antenna threaded to 91 LD fibreglass.

Asp has been tested at Naval Air Missile Test Center, Pt. Magu, California, and Naval Ordnance Missile Test Facility, White Sands Proving Ground, New Mexico, and is fired from a monorail launcher. It is a single stage rocket with telemetry head, missile body, motor case, and fin and aft skirt assembly.

Wasp

The *Wasp*, *Asp's* small brother, is manufactured by the same company. It is an extremely light-weight vehicle, and is intended for meteorological and other scientific research at moderate altitude. Two boosters are available for use with this vehicle.

TABLE NO. 7

RESEARCH ROCKET FACTS

ROCKET	Approximate NO. FIRED	Maximum ALTITUDE, Miles	DATE, FIRST FIRING
WAC-CORPORAL	10	71	26 September 1945
V-2	< 70	132	15 March 1946 (static firing, No. 1) 16 April 1946 (no. 2)
AEROBEE	< 200	164	24 November 1946 (No. A-4; A-1, 2, 3, were dummy firings) (First Aerobee-Hi; April 1952)
VIKING	13	158	3 May 1949
DEACON	70 <	< 100	21 August 1952

Contractor . . . Cooper Development Corporation.
Configuration . . . Single stage-boosted
Length, overall, feet 8.58
Length, rocket, inches 40
Length, booster, inches 63
Diameter, rocket, inches 1 3/8
Diameter, booster, inches 3
Weight, gross, pounds . . . 24 (Type-1 booster), 29 (Type-2 booster).
Thrust, Type-2 booster, average, pounds 2,000
Velocity, with Type-2 booster, mph. . . . . > 3400
Total time to peak, with Type-2 booster, seconds 100
Altitude, maximum, miles . . . 21 with Type-1 booster ..... 28 with Type-2 booster.
Launching technique . . . Adaptable for ground or shipboard launch.
Propellant .....Solid

Instrumentation for Research

In almost all high altitude research vehicles the problem of obtaining the maximum returns for each flight is becoming increasingly important. The use of large, high-cost military vehicles for this research has been abandoned, and since the newer rockets have limited payloads, instrumentation is becoming a one experiment proposition.

In determining the physical conditions of the upper atmosphere, a multitude of experiments have been conducted. These include studies with mammals and insects, wind at altitude, pressure, density and temperature measurements, upper air sampling, etc. Detection of micrometeorites and solar physics get special attention.

IGY Experiments

The IGY program starts this year. This concentrated effort on a worldwide basis should solve many fundamental problems. The U.S. will fire about 200 rockets, many carrying multiple experiments.

Definitely planned United States IGY experiments include:

Number of rockets to be fired	Experiments
60	Pressure, temperature, and density measurements of the atmosphere.
19	Radio propagation experiments.
115	Aurora measurements in Arctic and Antarctic.
10	Distribution of ozone determinations.
95	Earth's magnetic field measurements at high altitudes.
57	Cosmic ray studies.

TABLE NO. 8
GENERAL AEROBEE FIGURES

Background	Design and Development in 1946
Development	Applied Physics Lab. Johns Hopkins University; Aerojet General Corp.
First contract	U.S. Naval Bureau of Ordnance, May 1946
Later contracts	U.S. Air Force (ARDC), May 1949 U.S. Army, Signal Corps, February 1951
Stabilization	Fixed fins
Chamber cooling	Regenerative
Pressurizing agent	Helium
Booster thrust, Aerobee-Hi, pounds	18.000
Sustainer thrust, Aerobee-Hi, pounds	4,100 (Navy RV-N-13B) 4,000 (AF AJ 10-25)
Vehicle length, inches	283.4 (Navy RV-N-13B) 227 (AF AJ 10-25)
Diameter, inches	15
Dry weight, pounds	269 (Navy RV-N-13B) 300 (AF AJ 10-25)
Launch technique	150 foot tower

TABLE NO. 9
PERFORMANCE OF FIRST AEROBEE FIRING

Date	24 November 1947
Altitude, peak, miles	38
Velocity, maximum, mph.	2,100
Thrust, pounds	2,600
Firing time, seconds	36

TABLE NO. 10
TYPICAL AEROBEE-HI SPECIFICATIONS

Length, feet	23.58
Weight, loaded, pounds	1,482
Weight, empty, pounds	269
Weight, propellants, pounds	1,056
Propellants	Red fuming nitric acid/aniline-furfuryl alcohol
Thrust	4,000*
Booster, thrust, pounds	18,000
Booster firing time, seconds	2.5

*In 1949 the Air Force let a contract to increase the thrust to 4000 pounds.

TABLE NO. 11
RECORD AEROBEE-HI FIGURES

Model number	AGUL-0113C
Firing date	29 June 1956
Thrust, S.L., pounds	4,100
Specific impulse, second	200
Firing time, seconds	50.6
Acceleration, maximum, g	11.1
Velocity, maximum, mph.	4,600
Altitude, maximum, miles	164

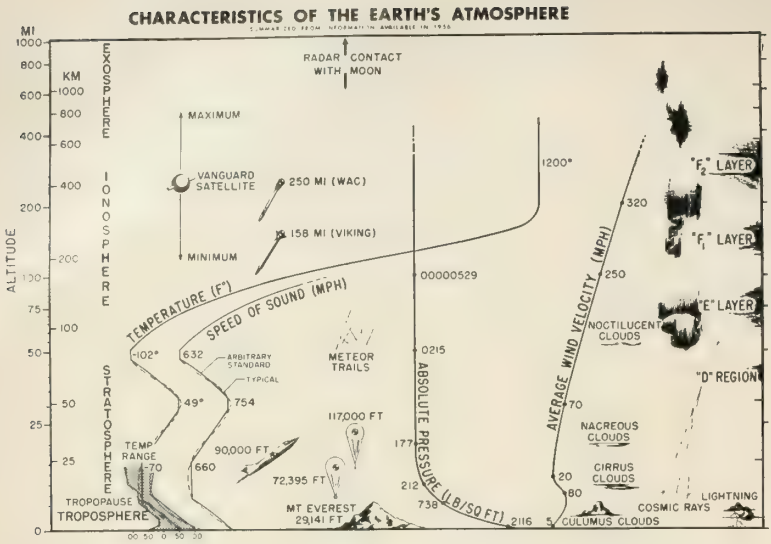
TABLE NO. 12
AIR FORCE AND NAVY AEROBEE-HI ROCKETS*

	Air Force Model	Navy Model
Maximum expected altitude, miles	150	170
Approximate payload, pounds	150	150
Late model designations	RTV-A-1A	RTV-A-10A, B, C

*Signal Corps models are XASR-SC-2.

TABLE NO. 13
NAVY AEROBEE-HI ROCKET FIRINGS

DATE	MODEL NO.	REMARKS
1954	RTV-N-10B	Successful test rocket. 98 miles altitude.
1955 (2 flights)	XRV-N-13	Hot gas pressurization. Improved thrust chamber. More propellants, carried in lighter tanks. Flights unsuccessful.
1956 (3 flights)	RV-N-13-A	Improved and lighter thrust chamber, more propellants, and other improvements. One lost, another reached 117 miles and the third, only 43 miles after thrust chamber failure.
1956 (1 rocket)	RV-N-13B	This used a standard 4,000 pound thrust Aerobee combustion chamber instead of the Aerobee-Hi combustion chamber. Flight NRL-50 reached a peak of 164 miles with a 145 pound payload (an altitude record).



Foreign Research Missiles: Few But Good

Like the United States, many other nations are closely concerned with research in the upper atmosphere. Among the foreign nations to participate in rocket experiments during IGY are: France, Britain, Germany, and Japan, with possibly a small contribution from Australia. Russia's status is not yet clear. It may be that she will carry out her own rocket program independently.

French Rocket Research

The postwar missile efforts of France through the Laboratoire de Recherches Ballistiques Et Aerodynamiques in Vernon have been varied and successful. Of the many fine missiles developed the most notable is the *Veronique*. This missile was developed under the Direction des Etudes et Fabrications d'Armement which is part of the Ministry of National Defense.

VERONIQUE Missile (Model NA)

Cognizant agency . . . Ministry of National Defense.
Length, feet 24
Diameter, feet 1.8
Velocity, mph 3,200
Firing time, seconds 45
Acceleration, g. 8.2
Altitude, maximum, miles 84
Payload, pounds 133
Weight, propellants, pounds 2,160
Weight, loaded, pounds 3,180
Propellants . . . White fuming nitric acid and deisel oil.
Alternate propellant .....Turpentine
Igniting system . . . Hypergolic igniter consisting of furfuryl, alcohol.
Stabilization . . . 4 delta shaped fins
Tank construction .....Steel plate
Telemetering system . . . Transmits 20 measurements proceeding from potentionometric pick-ups.
Carrier frequency, megacycles . . . 152
Spacing of impulses . . . The information signals offer the aspect of uniformly spaced impulses (intervals are 950 seconds, duration 100-750 seconds with a 4 microsecond interruption).
Ground reception . . . The time modulation is converted to an amplitude modulation by 2 different methods.
Improvements being made . . . These include a superior metal for the manufacture of the propellant tanks. Future performance should improve.

ATEF Missile

The Comité d'Action Scientifique de Défense Nationale of France has the following solid propellant ATEF under development.

Configuration . . . Three-stage (small)
Altitude, maximum .....50 miles
Status . . . In development (it is expected that the 50 mile altitude will increase as the model improves).

Japanese Research Rocketry

The Japanese contributions to research rocketry have been thoroughly covered in an article "Japanese Rocket Research," in the October 1956 issue of this journal. *Kappa*-128-J rockets have been fired from Akita Beach during the past year. Other rockets include a *Rockoon* system, the *Baby* series and the Pencil program.

German Rocket Research

It has been reported that the German Association of Rocket Engineers (AFRA) will fire research rockets from a Cuxhaven test base to altitudes of 12 miles during the IGY.

British Rocket Research

The British, who have so far given out very little information on their guided missile programs, have finally released details of their rocket contribution to the IGY program.

Their *Skylark* has been developed under the auspices of the Gassiot Committee, and the Royal Aircraft Establishment. The instrumentation is being devised and experiments conducted by several British universities.

Proving trials were scheduled to start at the end of 1956. If initial trials are sucessful it will be extended into the middle of 1957. First flights are expected at Woomera this spring.
Research programmers . . . Royal Aircraft Establishment & U.K. universities
Cognizant agency . . . Supply Ministry
Length, feet 25
Diameter, inches 17½
Payload, pounds 65
Altitude, miles .....76 (booster 132)
Burning time, seconds 30
Thrust, pounds 11,500
Propellant . . . Solid (Raven motor)
Stabilization .....3 fixed fins
Skylark nose cone, inches 65
Launching . . . . . From an 80 foot trainable launching tower.
Guidance .....Unguided
Instrumentation . . . Telemetry—Doppler & *Deacon* tracking equipment.
Experiments . . . Possible experiments to be made with these vehicles.

1. Temperature and wind studies at 30 to 100 kilometers using grenades.
2. Winds at altitude from 20 to 70 kilometers by radar tracking of chaff released from the rocket.
3. Sodium vapor experiments, using the sodium emission to be studied by an interferometric method.
4. Day and night airflow experiments.
5. Ion mass spectrometer studies.
6. Electron and ion concentration.
7. Electron densities using radio propagation techniques.
8. Pressure and temperature.

British-Australian ROCKOON

Another program under way in both Britain and Australia is that of balloon launched rockets. These launchings will be similar to the U.S. *Rockoon* project, and will be made during IGY. Balloon launch altitudes of 13 miles have been mentioned. Initial experimental firings will be made about the middle of this year by engineers of the Weapons Research Establishment, Woomera, South Australia. Reports indicate that the vehicle to be used in this balloon/rocket combination is 18 feet long and 10 inches in diameter. Peak altitude predicted is 60 miles. ★

IONS & PHOTONS

Speculating ahead to the days of intergalactic space travel, the popular press in recent weeks has blasted off on flights of fancy about the hardware "now being built" to enable man soon to traverse the void at the unrelativistic speed of 669,600,000,000 miles per hour—i. e., the speed of light.

Aside from shaking at least one learned ion and photon researcher's confidence in the language and the press, these stories have served to compound the misconceptions that prevail among the public.

However, Convair-Astronautics Space Flight Symposium last month should have served to sharpen perspective at least a little bit. In brief, the state of the art of ion and photon propulsion research can be stated thus: theories and paper work bounded by "if's" and "when's." Assuming sources of electric power and ions of compatible weights—yet to be realized—the technology of a nuclear-powered ion rocket is known in principle. In the case of the photonic rocket, the technology is not even known in principle. Work is all theoretical.

For Those Who Don't Know

The basic theories of both systems of propulsion is pretty simple. In the case of the photon, modern theory tends to discredit the simple mechanical wave theory of light, or at least to sharply modify it. The suggestion is that rather than light mechanically distorting a "jelly-like" ether into spherical waves, light is made up of elementary quanta—small indivisible bits—of light energy known as photons. But as mass has energy, so does energy have mass, and the mass of different photons, theory goes, can be considered as varying—with the mass of an infra-red photon, for example, being half that of ultra-violet. Or, looking at it another way, ultra-violet photons have twice the energy of infra-red photons.

An ion, in general terms, is an atomic or molecular system that is mechanically balanced but electrically unbalanced. The metal sodium, for example, has one planetary electron in its outside ring. Mechanically, it "wants" to get rid of this "extra" electron so that the then-outside ring (the one remaining) will have eight. Similarly, a non-metal like chlorine has seven planetary electrons in its outside ring; also wants eight. Transfer sodium's extra electron, and the mechanical wishes of both elements are fulfilled. But they are electrically unbalanced, sodium being positive and chlorine being negative. So they stay together as sodium chloride—common salt.

However, separate them, as when they go into solution or upon the application of energy and the resultant electrically unbalanced particles are ions, both negative and positive. Being charged, they can be accelerated to very high velocities by electrical and magnetic fields. Accelerating suitable ions in this fashion is the basis of the ion rocket. It is something that is already done in the laboratory and with particle accelerators like bevatrons, cyclotrons, etc. The problem in adapting this principle to propulsion is the weight of equipment for producing power and handling all the functions that have to be handled.

The principle of photon propulsion is $E=mc^2$, where E is the energy produced; m, the mass; and c, the speed of light. It is Einstein's basic mass-energy relationship.

Dr. Ernst Stuhlinger of Redstone figures ion propulsion units could be designed to produce exhaust velocities of 100,000 meters per second and with an acceleration of 0.0001 gravities. Obviously such a system would be useful only after escape from nearby gravity fields had been accomplished.

Photon propulsion, however, contemplates conversion of mass with 100 per cent efficiency. Exhaust velocities of 300,000,000 meters per second would be achieved and produce an acceleration of one-to-two gravities. Unfortunately, nobody has a conclusive idea at the moment of how to accomplish mass-to-light conversion.

Comparison of different space propulsion systems.

Propulsion System	*Exhaust Velocity m/sec*	*Acceler. g*	*Power/-Thrust kw/kg*	*Technical Feasibility*
Chemical	3,000	1 to 8	15	Technology proven
Nuclear or Solar Power plus light gas	4,000 to 6,000	.01	20 to 30	Technology known in principle
Nuclear power plus ions	100,000	.0001	500	Technology known in principle
Phototonic	300,000,000	1 to 2	3×10^6	Technology unknown

Space, times and distances of space flight showing differences between ship time and earth time as affected by Einstein's time lengthening principle.

T r i p	*Mass Ratio*	*Ship Time*	*Earth Time*	*Distance*
Half around earth	1.00007	47 min.	47 min.	2×10^4 km
Moon	1.0003	3.5 h	3.5 h	4×10^5
Planets	1.006	2 d	2 d	10^8
d Centauri	20	3.6 y	6 y	4×10^{13}
Center of galaxy	10^4	20 y	6×10^4 y	2.8×10^{17}
Andromeda nebula	10^{11}	26 y	2.5×10^6 y	7×10^{18}
Round trip through Universe	10^{10}	42 y	4×10^9 y	3.2×10^{22}

Plastic Balloons in the Rocket Age

. . . the giant offspring of the refrigerator bag helps speed space flight

By Otto C. Winzen

AS M/R GOES TO PRESS, three *Rockoon* flights are being made off Guam. Tests are being conducted at the Atomic Energy Commission's Nevada test site 70 miles northwest of Las Vegas to determine the feasibility of using plastic balloons to carry aloft a nuclear device for detonation experiments. The Navy's Projects *Skyhook*, *Rockoon*, *Strato-Lab*, and the Air Force's Project *Moby Dick* and its animal cosmic ray flights have contributed much to upper air research.

These operations point up the significant role plastic balloons are playing in space study. The October issue of m/r contained an interesting article by Kurt R. Stehling and Richard Foster discussing how a four million cubic foot plastic balloon could be used to carry to 70,000 feet a solid-propellant three-stage rocket capable of carrying a four-pound payload to the moon.

Stehling, as early as mid-1955, suggested a balloon launching method for small orbital satellites. A 3,000,000 cubic foot plastic balloon would be used to carry the proposed three-stage vehicle weighing 13,500 pounds to 75,000 feet for launching.

Small solid-propellant rockets have been successfully launched from balloons for some time. The idea for balloon launched rockets, using a cluster of balloons, was first shown in a 1947 report to the Navy by the author.

The first balloon-rocket combination was developed by Dr. James A. Van Allen of the University of Iowa's Department of Physics for the Office of Naval Research in 1952, as an inexpensive means of conducting cosmic ray research at altitudes beyond the range of the *Skyhook* balloon itself.

At about the same time the first Aerobee was being developed, the author and his associates had successfully flown the first plastic *Skyhook* balloon (OCW patent 2,526,719) on September 25, 1947. It reached an altitude of 100,000 feet and precipitated the Office of Naval Research Project *Skyhook* program designed to study cosmic rays, temperature and density of the atmosphere, and other high-altitude data.

Van Allen realized that it would be some time before upper-atmosphere research firings of large, expensive rockets could be conducted on the comprehensive world-wide basis necessary for obtaining a wide variety of scientific data. As a consequence, he devised the inexpensive *Rockoon* system with which it has been possible to explore altitudes up to 65 miles with balloon and rocket costing altogether about $1,500.

The current *Rockoon* flights are a preliminary to upper air research to be conducted during the International Geophysical Year. Such launchings are made aboard ship away from inhabited land areas and established air and shipping lanes. *Rockoon* launchings have been made by WRI and General Mills, Inc. for the Office of Naval Research from waters off San Diego, Greenland and Guam.

The 12-foot *Deacon* weighing 184 pounds is one of the rockets which is sent aloft suspended from a 72.3 foot diameter plastic balloon of 150,000 cubic foot volume. The balloon carries the rocket to an altitude of approximately 80,000 feet, where it continues to float until the decision to fire is reached. During the experiments last summer, the USS Colonial served as the launching vessel, the destroyer USS Perkins tracking the balloon with radar. When a decision to fire has been made, the rocket igniter is fired by radio control from the ship.

Used in the *Rockoon* expedition was the 72.3-foot diameter Winzen balloon made of .0015" gage polyethylene plastic film with integrally heat-sealed load bands. There were no balloon failures in 27 launchings of this type. All balloons had reefing sleeves, and weighed an average of 115 pounds.

Suspended from the balloon by a 100-foot nylon line is the *Deacon* rocket. The line terminates in a steel ring on which is hooked the rocket motor. The hook is placed so that the rocket axis is inclined at an angle of 7.5 degrees from the vertical. At the moment the rocket is actuated, the hook slips out of the ring and the rocket shatters the balloon. In the next 90 to 120 seconds, the rocket attains an altitude of 60 to 70 miles above the earth's surface. In its trajectory it telemeters data on the strength of radiations to the observing station aboard ship. The rocket-balloon combination was usually launched during the morning while the ship moved in the direction and at the speed of the wind. It was committed to firing within approximately eight hours of flight time.

The load line of a typical *Rockoon* flight consists of the following instrumentation. First, a safety control instrument designed to release the load in case of balloon failure and/or after a predetermined length of time has elapsed, to insure that the rocket will be jettisoned before drifting out of the control area. Next, there is a radiosonde (400 MC) or a WRI beacon which telemeters continuous altitude data and serves as a DF tracking beacon. Next there is often a series of radar corner reflectors. Finally, there is the rocket with its firing box which allows for a 30-second time delay to permit the electronic rocket instrumentation to reach operating temperature. The *Deacon* rocket is normally covered with a loose plastic envelope to prevent convective cooling during the ascent through the extremely cold tropopause without reducing heating by solar radiation.

When fired from the White Sands Proving Grounds, the *Deacon's* maximum altitude did not exceed 100,000 feet, due primarily to aerodynamic drag in the lower atmosphere. A tremendous boost in altitude is achieved by launching the same rocket using a balloon as the launching platform.

Payloads in the nose cone of the *Deacon* range from 20 to 60 pounds depending upon the maximum altitude desired. If electrical potentials over several hundred volts are to be used, a sealed nose is necessary so that sea-level pressure can be maintained in order to reduce the risk of corona or arc-over at high altitudes.

Following a series of three test flights of fully-instrumented rockets launched at White Sands Proving Ground in June and July 1952, the first real test of the *Rockoon* system was made off Greenland above the Arctic Circle in August 1952 for the purpose of cosmic ray investigation.

Seven successful flights were made during the initial tests, one of which was launched at 57,000 feet and reached an estimated altitude of 295,-000 feet. No significant deviation of the trajectory from the vertical occurred. Since then, rockets have been launched from balloons as high as 90,-000 feet, carrying payloads of 30 pounds into the D-region of the ionosphere and well into the E-region for a vehicle cost of less than $2,000.

Additional cosmic ray flights were conducted off Greenland in 1953, 1954 and 1955. This area was chosen because it is near the geomagnetic pole which competes with the geomagnetic equator (off Guam) as areas of special interest to cosmic ray scientists.

Even higher altitudes may be reached using the *Rockoon* system for launching inexpensive two-stage solid-propellant rockets. The October 1956 issue of m/r disclosed first details of successful flight tests using a combination of a *Nike* missile booster and an Allegany Ballistics Laboratory *Deacon* sustainer as a two-stage rocket called *Dan* for meteorological sounding at extreme altitudes.

Two test firings of the *Dan* rockets indicated that when launched from the ground, altitudes between 385,000 and 487,000 feet may be reached with payloads ranging from 10 to 60 pounds. The complete weight of the *Nike* booster was 1,324 pounds and the *Deacon* 216 pounds, giving a total weight of 1,540 pounds. Plastic balloons are currently available for carrying a *Dan* rocket to an altitude of 70,000 to 90,-000 feet. This would mean that the *Dan* could be fired above 97 per cent of the earth's atmosphere and would reach substantially higher altitudes than when launched from the ground.

In July 1955 Kurt R. Stehling suggested a method for balloon-launching an earth satellite rocket. Even more recently, he has proposed using a giant plastic balloon to carry to 70,000 feet a solid-propellant step-rocket capable of carrying a four-pound payload to the earth's satellite.

Recent progress in the development of heavy-duty plastic balloons cause projects of this type to take on new meaning. It now appears feasible to carry aloft the orbital rocket vehicle Stehling suggests with existing balloon equipment and launching methods.

The 2,000,000 cubic foot WRI balloon would be able to haul a 12,000 pound rocket to an altitude of almost 60,000 feet. The 3,000,000 cubic foot balloon, now also in production, will carry this load to approximately 67,000 feet. The proposed 5,000,000 cubic foot balloon, weighing 2,000 pounds, should reach an altitude of 75,000 feet.

Main advantage of the larger balloons lies in their increased load carrying ability. In one launching method developed for ONR by WRI for Stratolab heavy-duty plastic stratosphere balloons, the aerostat is launched from the bottom of an open pit iron mine. Other launching techniques, including shipboard launchings, are considered practical with heavy loads. More work is necessary in developing cluster balloon launching techniques for greater loads or higher altitude.

The development in 1955 of a balloon construction with integrally heat-sealed load bands enabled the construction of a balloon which would carry heavy loads without placing undue stress upon the plastic balloon film. In the original *Skyhook* plastic balloons, adhesive load tapes were used but the adhesive failed to adhere at low temperature in the stratosphere, made prolonged storage impractical, and such tapes could not be applied uniformly along the meridians. This resulted in balloon failures. The heat-sealed load bands eliminated these difficulties.

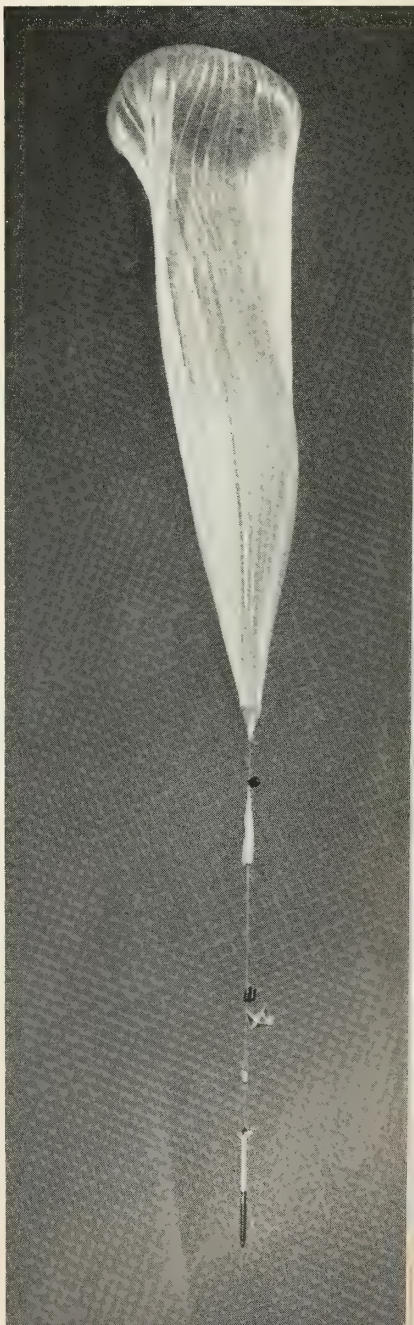
Load bands are available with glass fiber, nylon and fortisan filaments with high breaking strength. They transmit the lift from the fabric to the load along equally-spaced meridians of the balloon. The fabric then serves primarily as a barrier material for the lifting gas and secondarily as a load-carrying member, not as the main load carrying member as in the case of the former rubberized-fabric balloon.

The load-bands of the desired breaking strength are heat-sealed into the seams of the gore material. In the two million cubic foot heavy-load balloon, there are a total of 120 stressed load bands. The balloon shape is determined on the basis of minimum latitudinal stresses for a given fabric, weight and load.

While the balloons discussed here employ two mil gage polyethylene, heavier or stronger materials are available as are load bands of several times the 500-lb. test bands used in the two million cubic foot heavy-load vehicle which has a theoretical bursting strength of 20,000 pounds.

WRI, in addition to other balloon instrumentation, has developed several positioning devices to provide precise firing orientation. These are simple servo systems originally developed with ONR to orient cameras along a given azimuth and elevation for the purpose of astronomical studies from balloons. The plastic stratosphere balloon floating at ceiling altitude represents an extremely stable platform free from oscillation and of very low rotational

Rocket goes aloft by plastic balloon.



velocity. A carefully designed rocket suspension system can therefore be maintained in a known attitude without difficulty. Stability along the vertical axis is not a critical problem.

For the azimuth angle of the rocket, the servo systems developed employ an earth-inductor compass as a reference and the payload is rotated against the inertia-mass of the balloon which is of a very high order of magnitude. Two systems have been designed. One, automatic, in which a rocket could be held in an attitude of a pre-set direction and elevation automatically. Two, controllable, in which the attitude of the rocket could be changed at will from the control center on the ground by radio command.

Both systems will telemeter attitude angles to ground stations. The resolution of such systems can currently be held at least to one degree with closer control possible. The orientation devices are simple since they needn't include gyro-stabilization.

A further extension of the use of balloons in rocket research would be the use of a five million cubic foot balloon to carry aloft research gliders or rocket planes. The weight of present research rocket planes is in the vicinity of 10,000 to 16,000 pounds. The aircraft could be carried to a height as great as 80,000 feet on the five million cubic foot balloon before it is released. Ascent time would be one and a half hours. Cost would be less than the present method of taking research rocket planes aloft by a mother plane. Release altitude would be 40,000 to 50,000 feet higher, and the plane could spend a greater portion of its flight time at high altitudes.

One disadvantage of this system would be the absence of attending personnel such as are present in the mother airplane. This could be remedied by using a gondola which would contain personnel and equipment and power for monitoring the aircraft during the ascent, and assisting in the launching of the rocket aircraft. Assuming a gondola weight of about 2,000 pounds, the launching altitude would be reduced only 3,000 feet using a five million cubic foot balloon.

Round the World Balloons

A recent issue of *Newsweek* suggests that upper atmosphere researchers are considering putting their instruments aboard around-the-world balloons which would be slow-freight companions for the artificial earth satellite. One handicap to tracking the satellite from ground stations presently proposed would be the difficulty in doing so during extended periods of bad weather. A balloon gondola suspended in space with two observers could visually track the satellite by telescopes without having to worry about weather. The capability now exists to maintain such a space laboratory aloft at an altitude of 80,000 feet for a week. It would be hard to imagine a better observation platform for tracking the satellite than such a space station. When aided by the jet stream at the base of the stratosphere, circumnavigation of the earth could be accomplished in 100 hours or less. It would also give *Vanguard* scientists an opportunity to check out their airborne and ground equipment devised for the tracking of the satellite.



Rocket launching balloon at its peak altitude, as photographed through telescope.



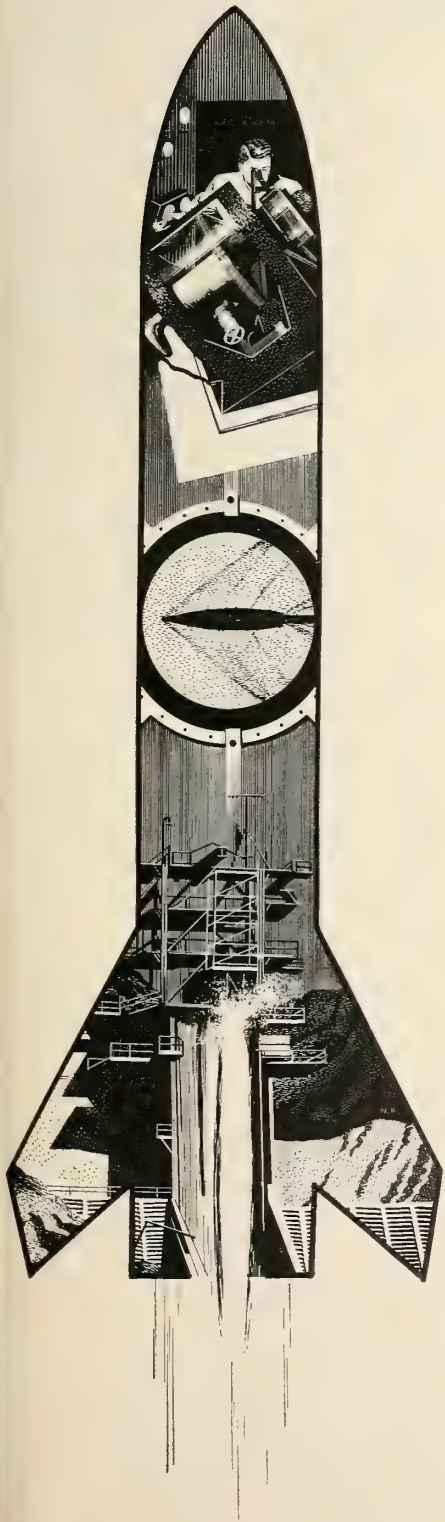
Plastic high-altitude rocket research balloon being inflated at night.

Much of the balloon's work is done at lower levels. Its feats of endurance and long distance voyages are nothing short of remarkable as it floats for days over oceans and continents.

The balloon floating at altitudes currently up to 145,000 feet is a floating laboratory—an ideal observatory as demonstrated by the University of Minnesota—as it hangs motionless with respect to the surrounding atmosphere. In a sense it is a satellite of the earth. It is a stable platform ideal for the execution of research experiments.

So the balloon, man's oldest aerial vehicle, and the rocket, man's newest aerial vehicle, have been linked in discovering the secrets of space. ★

Special 111-conductor Rome cable solves tough guided missile problem



When project engineers at North American Aviation, Inc., needed a special telemetering cable for their advanced guided missile work at various missile test centers, Rome Cable Corporation was asked to make it.

The cable was a tough one to manufacture. The specifications called for exacting dielectric requirements, low-loss characteristics, adequate service life—and a total of 111 conductors—all contained by one heavy-duty jacket.

Because Rome Cable engineers are accustomed to solving tough cable problems like this, they readily produced the cable which met North American's rigid specifications. Rome RoLene—a polyethylene compound—proved perfect for insulating the 37 triplets inside the jacket, and it easily met the specification requirements calling for controlled capacitance and uniform wall thickness. Rome Synthinol, a tough polyvinyl chloride compound, proved to be an excellent jacket material.

Rome Cable can also help you

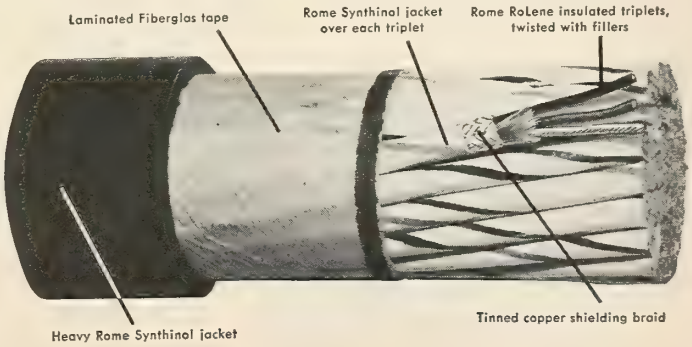
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Astronomer Fred Whipple

. . . wants more basic research by Defense Department

. . . urges start of post-Vanguard projects now

Last month Defense Secretary Wilson abolished the office of Assistant Secretary of Defense for Research and Development and combined its functions under the newly established Assistant Secretary for Engineering and Research. This personal report *emphasizes the growing danger of de-emphasizing basic research in the Defense Department. Astronomer Dr. Fred Whipple is the country's leading upper air researcher. He knows the increasingly close relationship between basic discovery and modern weaponry. He has been a proponent of space flight for many years.*

Q. *Dr. Whipple, you are Chairman of the Upper Air Rocket Research Panel. Is that right?*

A. Yes. I wear several hats. I'm professor of astronomy at Harvard. I'm also Director of the Smithsonian Astrophysical Observatory. My interest is basic research. As you well know, that's the spring that feeds all the rest. If it dries up, we're out of luck.

Q. *Do you feel we're spending enough money on basic research?*

A. It's not so much the amount of money we're spending, but the way it's spent. Many people in basic research cannot or do not plan ahead.

Q. *Do you feel a Czar is needed to coordinate and direct basic research in this country?*

A. You do not need somebody to coordinate or organize basic research. You need enough communication so that the interested scientist knows what others are doing. And you need enough continuing long-range support so that they know what they can do. If you provide communications and continuity of funds, then you don't have to coordinate; you don't need a czar in basic research. This is a critical point, because in development you do, and when you get to hardware you certainly have to have it. But in basic research, freedom is essential.

Q. *Is communication satisfactory the way it is now?*

A. I'm not sure it is for all basic research. It is, for example, in terms of upper air parameters. There, we're dealing entirely with unclassified material. The weakness is in funding procedures. Research contract renewal too often takes place after the end of the previous year's contract. It takes a research man with a lot of persistence to get into this when the funds are so erratic.

Q. *Is this a function of the Congressional method of making appropriations?*

A. Partially, though I think Congress is very appreciative of these problems and has done very well. It is simply that there are a lot of steps in the chain. You can have high level policy; you can have Congress saying "we want basic research done"; you can have the Bureau of the Budget backing them up; you can have top-flight Defense men in each of the services backing them up. But by the time it gets down through the chain of command and the various people, the original intent is lost. Long-range programs, thus, are very difficult to set up.

Q. *Since World War II, haven't we established different organizations—Office of Science Research and Development, National Science Foundation—that are supposed to do precisely this?*

A. Yes, and given time, I think the National Science Foundation will do so. It had very limited backing at the beginning, but it's probably growing now about as fast as it can and still be effective. There is a point I want to make here. I feel more basic research should be conducted within the Defense Department. The policy of removing basic research from Defense which unfortunately still continues is, I feel, basically unsound. The military must make extremely grave decisions in guiding the future of our defense. The instrument of war a decade from now is perhaps still a spark in some scientist's head today. Now these decisions must always be made by administrators essentially in the Defense Department. If they have research scientists in their organizations who also are constantly aware of defense needs, then those men will have good judgment and can advise their administrators wisely. If, however, Defense administrators must go to outside consultants, then they are going to get good judgment in regard to science, but they are probably not going to get good judgment as to its utility as a weapons system. They must have research scientists—and I rather stress this point—must be research scientists within the Defense Department because no scientist who has given up his research and gotten into heavy administrative work can have this judgment any more. I think he loses it very rapidly when he leaves his laboratory and his pure research interests. Now good scientists who work in Defense tend to leave.

Q. *He goes into industry and becomes a project engineer which is heavily administrative. He's good, Because he's good, we lose him.*

A. Right. In Britain, it's said, if a man proves himself a good scientist, they give him three assistants and tell him to go ahead. In America, everybody pats him on the back and gives him three new jobs. I'm afraid there's a little truth to this.

Q. *In this regard, there's another advantage British scientists have, though we might consider it as a disadvantage. They lack money. They can't use the shotgun approach to a problem. They have to think it through first. They say; "There are a hundred possible ways of doing this"—They figure out the best ten and then maybe choose three of them. This is what they did in their atomic power program. It requires a lot of good, clear, careful thinking before you mount a test tube or turn a lathe, so to speak.*

A. This is relevant to the point I made a moment ago about the need for the basic research scientist in the Defense establishment. They can point out those areas that

are most likely to succeed. If we have lots of money, we can apply the shotgun technique. The difficulty is that nobody then has the courage to cut off useless, unpromising development. Basic research should be judged by its quality, not by whether it is successful or promising. Development, on the other hand, must be judged as to whether it is successful and promising and you must cut off development when you see you are going down a blind alley. In Basic research you must explore all these alleys because they may turn out not to be blind after all.

Q. *Negative results are answers as well.*

A. That's the point.

Q. *Do you feel defense has a proper appreciation for basic research?*

A. My impression has been since World War II that the group of people most appreciative of basic research in this country, outside the universities, is the military. But there are certain policy matters that get the thing tangled up.

Q. *What do you think the primary function of an organization such as the National Science Foundation should be in the case of basic research?*

A. It should determine the needs and help fund them on a long-term basis. NSF can do this if it is given further backing by Congress so that it can grow to a larger size.

Q. *Do you think it would be a good idea for the Defense Department, say once a year or so, to sponsor basic research symposiums in different fields, such as upper air research, inviting people from industry, universities and the three services to discuss problems and progress?*

A. I certainly think it would. I want to make it clear that quite a bit of my criticisms are broader than upper atmospheric research. I've talked about basic research generally, materials, solid state physics, etc. All are relevant.

Q. *Can you state briefly where knowledge begins and leaves off in upper air research?*

A. First, you must know how much air is up there. We can do very well to something like 100-to-150 miles with sounding rockets. Then the rocket technique essentially fails because the density is too low for the instruments. Also the outgassing of the rocket provides more gas density than the air. You must leave the rocket up there long enough to de-gas, which obviously you can't. Then you have the problem of ionization. This affects communication. Astronomical methods, radio astronomy, reflections from the moon will tell you the total electron content of the entire ionisphere all the way to the moon and back again. The problem of telling the distribution is difficult. Then another area in which we know nothing of these high altitudes concerns magnetic fields. In all these cases we have to turn to the satellite.

Q. *Won't magnetic measurements require a heavier satellite than the Vanguard?*

A. It's hoped that six pounds will do it.

Q. *Would the six pounds provide for continuous readings in flight or would it store the data and play back?*

A. It would probably take periodic measurements and play them back over telemetering stations.

Q. *On returning to earth, at what altitude would the satellite get so hot it ceased to function?*

A. Well, in a nearly circular orbit that is contracting, it will begin to become hot at some 40 miles.

Q. *Can you tell us something of the latest plans for launching satellites during the International Geophysical Year? Aren't we going to launch something like 10 or 12?*

A. That was the original plan, but that has been cut back to six. The optimists say we're going to get most of them up, and on the other hand the pessimists say, well, we might not get any up. I think the expectation of those closest to it is that about two out of six will be successful.

Q. *What's the criterion for success?*

A. That it goes into an orbit with a minimum perigee of 200 miles and an apogee of anywhere from 300 to 1500 miles. In an orbit of this sort, it should stay up for about a year. The program as it's planned now, includes four prime experiments. After at least one or two shots for testing, Number One will carry experiment Number One. If the satellite is successful, satellite Two carries experiment Two. But if One fails, satellite Two will carry experiment One. If that also fails, satellite Three will carry experiment Two. Each experiment gets two chances. Now, of course, that doesn't guarantee that Four gets to fly at all.

Q. *If the Army Ballistic Missile Agency were to come up with another launching vehicle, as they claim they have, is there anything in the nature of IGY to prevent the use of launching methods other than* Vanguard?

A. I would put it this way. In order to put a satellite in another vehicle, it would have to have different dimensions and would have to be integrated to that vehicle. And it's probably too late now to start any new plans for the period of the IGY.

Q. *What about follow-up satellite plans to continue on where the IGY program leaves off?*

A. Well, they should have been started by now. This illustrates the research planning problem I mentioned earlier. There are a number of people who would like to start working on experiments for satellites. It takes a long



Don't need a czar . . .



In basic research, freedom is essential.



Negative results are also answers.

time to develop those things, and the more time you have the better you do. Two years is not a long period at all.

Q. *In the IGY, you're concerned with tracking the satellite aren't you?*

A. Yes, one of our big projects is the satellite tracking camera.

Q. *How many of these are you going to make?*

A. Twelve—only two to be stationed in this country near White Sands and in Florida. Others will be in the Netherlands Antillies, Peru, Argentina, South Africa and Australia. That's seven. Five will be stationed around the earth between 35 degrees north and south latitude—Hawaii, Japan, India, Iran or Egypt and Southern Spain.

Q. *You're not sending one to Russia?*

A. No, we haven't been invited to send one. But the primary reason is that we're trying to space them in the low latitudes.

Q. *Has there been much liaison with the Soviet Union in this program? Sedov at Rome and Bardin at Barcelona made statements, for example.*

A. That's right. I saw Bardin at Barcelona. They have made no embellishments on these statements whatsoever on an official basis. They indicated they were going to cooperate, but from my knowledge, no official information has come from them concerning the obvious questions you would ask—what, when, where?

Q. *Will any of the satellite experiments be designed to contribute to the basic study of matter, subnuclear particles, for example?*

A. Nearest to it will be the studies by James Van Allen, Iowa State, of cosmic rays, high energy problems. Of course there are those who would like to plan more fundamental experiments, particularly to distinguish between two types of time as suggested by Milne many years ago—astronomical time and nuclear time—to see whether there is a fixed relationship between them as modern physics assumes. Dr. Markowitz at the Naval Observatory has a program on this, carried out with cesium clocks on the one hand and moon clocks on the other. He expects some sort of answer to this by, I believe, 1973.

Q. *Suppose the relationship does vary. Where does that leave us?*

A. Just one step further along the way—one step further into mystery. This is the way science progresses.

Q. *What about Einstein. Will the satellite be used to confirm time lengthening or other Relativity postulates?*

A. Probably not in the IGY satellites, though nearly everyone interested in the field seems to think it might be possible. You have to be able to put an atomic clock in a satellite. Those now in use weigh hundreds of pounds. I've talked to Professor Zacharias at Cambridge about this and he thinks he might get one down on the order of 50-to-60 pounds, including power supply.

Q. *If the satellite stays up a year, would it be possible to confirm the perigee advance?*

A. I think not, because of the amount of interplanetary material as well as what we might call high atmospheric material. This would have too much of an effect on the satellite's orbit for the very small perigee advance to be measured. In order to overcome this uncontrollable margin of error, your satellite would have to be on a pretty grand scale.

Q. *What is the outlook for making visual observations by satellite?*

A. Well, I do not take very seriously these manned satellites as being the proper answer. The next step is a large enough satellite and a small enough power supply, nuclear or solar, that they can be brought together with very moderate weights—100 pounds or so. Then you can put in television. This opens a whole new area of research that cannot be done by the IGY satellite.

Q. *How about a telescope in the satellite?*

A. Well, a 40-inch reflecting Schmidt, though with a somewhat longer focal length than the Palomar Schmidt, would give you all the resolving power of a 200-inch telescope under the atmosphere. Also, you could do tricks with pairs of interferometers. An interferometer on earth is limited to something like 20 feet before the atmospheric scene knocks it out.

Q. *Are there plans for capturing and identifying such things as subnuclear particles?*

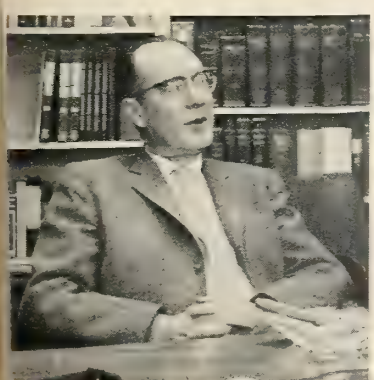
A. Yes, possibly from the sun. I'm extremely interested in micro-meteorites, the fine dust in space. We know very little about this dust in outer space.

Q. *How are you going to study these?*

A. Well, some have been brought back on rockets with plastic surfaces.

Q. *Will you have devices on one of the IGY satellites to tell if a particle hits?*

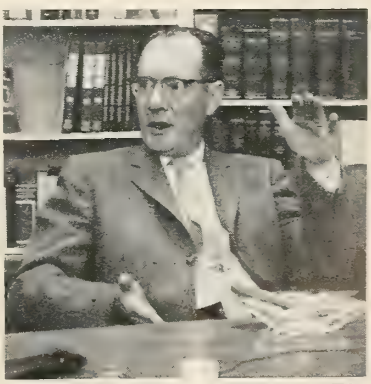
A. Yes, in the first satellite experiment (Naval Research Laboratory) there will be pressurized sections which larger dust particles would puncture. We can record this with telemetering equipment. We will also measure sound. Through a combination of all these I think we will get some answers. ★



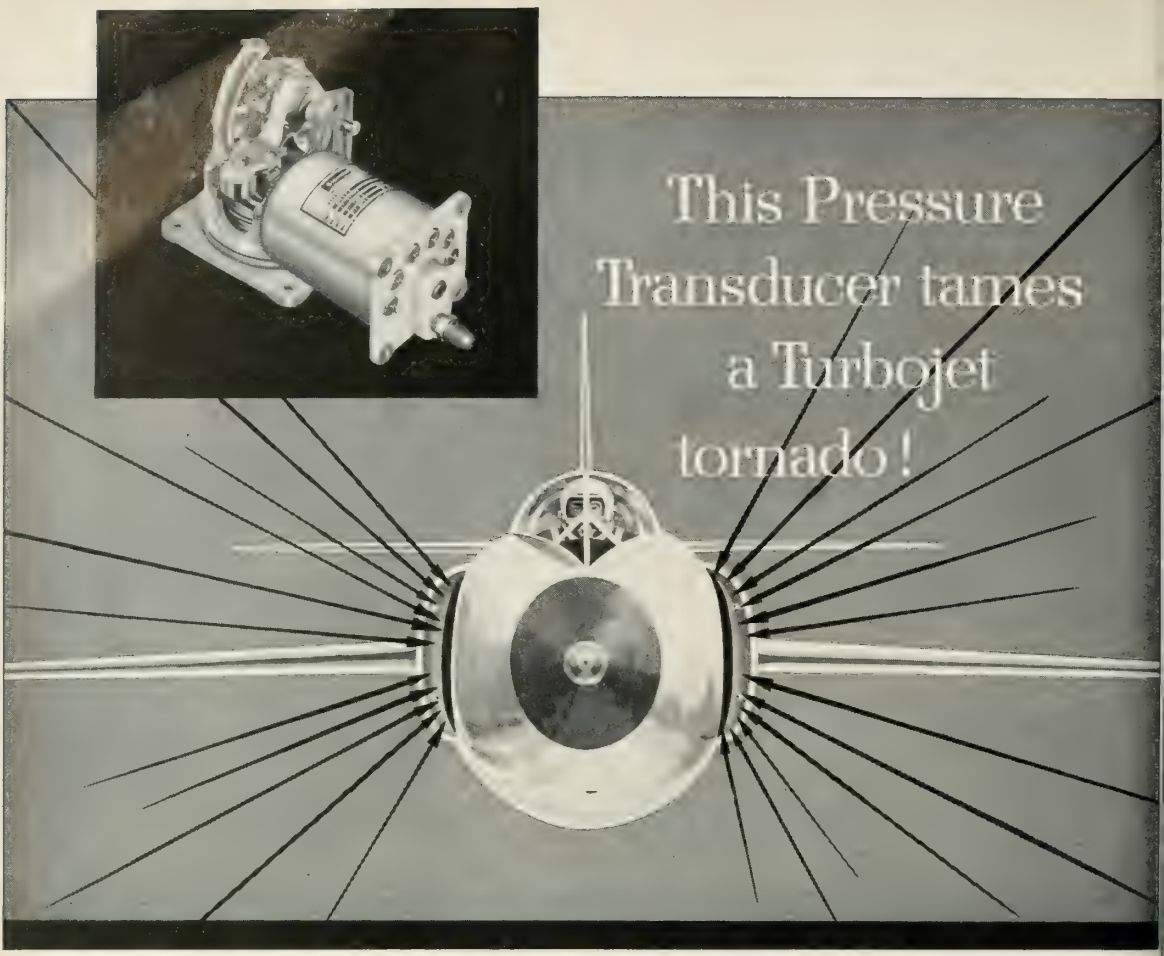
We have to turn to the satellite.



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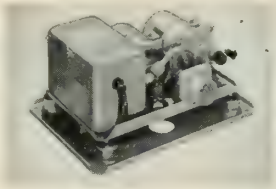


Controlling the tornado of intake air consumed by supersonic jets is the latest assignment of Giannini's High Resolution Pressure Transducer. This versatile instrument plays a key role in maintaining optimum efficiency of today's newest and most advanced high performance turbojet engines.

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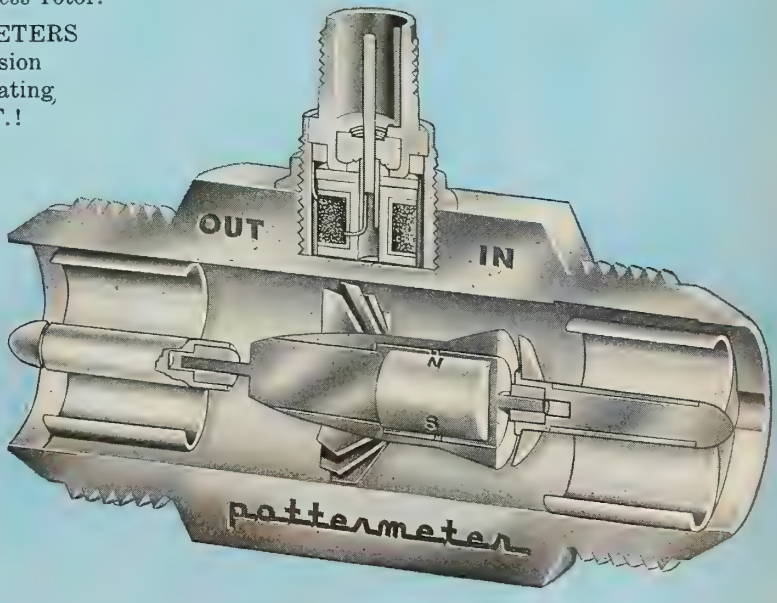
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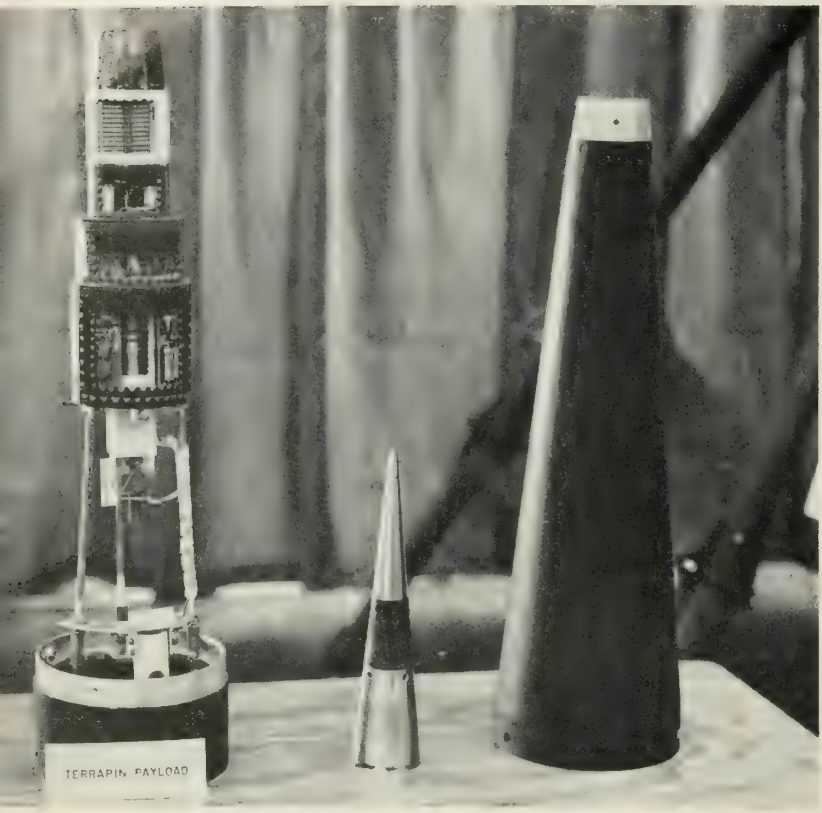


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TERRAPIN ---

the do-it-yourself rocket



TERRAPIN instrumentation payload including radio transmitting antenna and nose cone. Its nose cone section can be varied in length to accommodate equipment weighing from four to 24 pounds.

The reason for it all—payload containing power supply, telemetering equipment, accelerometer, spin detector, and other test gear is fitted in place. TERRAPIN breaks down for easy transport.



By Professor S. F. Singer

Physics Department
University of Maryland

THE BASIC FUNCTION of a University is teaching, and the justification for research at a university is that it is the best method for teaching advanced work. At the present time, when there is a great demand for trained scientists in the field of rocket technology, telemetering techniques, upper atmosphere physics to name just a few, there is a woeful lack of facilities for training such personnel.

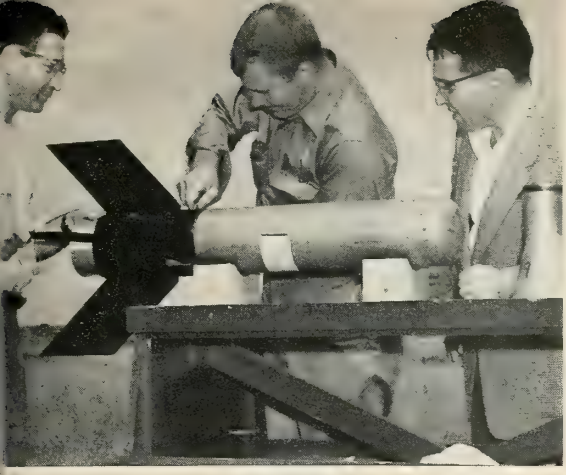
It is of greatest importance from a national point of view, as Captain Grayson Merrill has pointed out, to establish such training for qualified young engineers and physicists at academic institutions of higher learning.

One of the best means of carrying on a graduate teaching program in these fields is through the medium of high-altitude research with small rockets. This work embodies all of the technological phases, such as rocket propulsion, aerodynamics, telemetering techniquies, electronic instrumentation and in addition, it provides an opportunity for research in upper atmosphere physics, cosmic rays and other extra-terrestrial radiations. These fields of research have basic significance for geophysics, astrophysics, and in general, give us a better understanding of the environment of the earth. This research will gain considerably in practical importance as means are developed for projecting vehicles into the space around the earth.

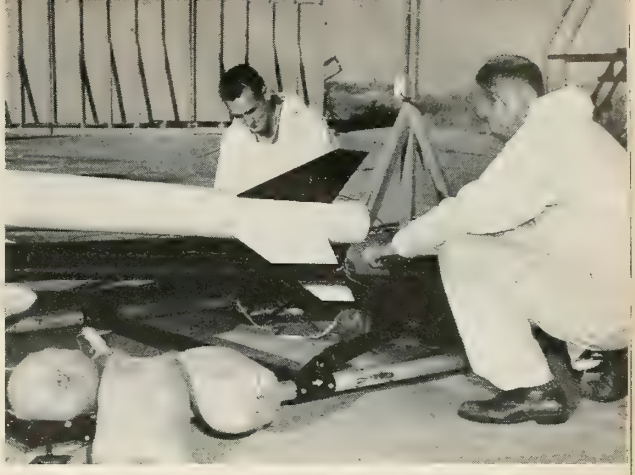
2.75-in. FFAR costs $50

A number of universities are now involved in high altitude rocket research: Colorado, Iowa, Michigan, Utah, to name just a few. Here at the University of Maryland we are doing high altitude research by concentrating on the small research rocket, with emphasis on the word "small." We started out by undertaking the development of an aircraft launched sounding rocket, the little 2.75 inch FFAR which weighs only about 15 pounds and costs $50.

Our first task was to squeeze into its tiny warhead, a few cubic inches: a cosmic ray counter, high voltage supply, premodulator circuits, 403 mc transmitter, and of course batteries to drive the instrumentation. Through co



Attaching TERRAPIN'S second-stage rocket engine assembly to second-stage fin section. Left to right: Republic Guided Missiles Div. Project Engineer MORRIS ROTH, NACA's GEORGE CUTTER, and SIDNEY HELFMAN, Republic's Aerodynamics Div. Chief.



Attaching firing box before raising TERRAPIN on its zero-length launcher are ROY HINDLE and EDWARD MATHEWS of NACA. First firings of the TERRAPIN were conducted jointly by representatives of Republic Aviation, NACA and Maryland University.

operation with the Office of Naval Research we arranged for 5 test firings and although reasonably successful, it soon became apparent that dependence on an aircraft is not very satisfactory for a university operation. We needed a do-it-yourself, or rather launch-it-yourself vehicle.

We therefore concentrated next on a two-stage ground-launched rocket following a general scheme pioneered by the NACA, but again on a much smaller scale. In collaboration with Republic Aviation we designed the *Terrapin* high altitude sounding rocket, a 200 pound midget, consisting of a modified ABL *Deacon* first stage and a *Thiokol* T-55 second stage. This rocket with some slight modifications is capable of carrying 25 pounds some 80 miles into the ionosphere and is becoming our work-horse for upper atmosphere experiments.

Initial instrumentation on the *Terrapin* was concerned as much with sending back readings on the rocket itself as it was with sending back readings on the upper atmosphere. This was necessary to check the performance of the vehicle itself, since being a new configuration, it had never been fired before.

Ease of Handling, Launching

The great advantage of the small rocket is its ease of handling and launching. In the case of the ground-launched rocket vehicle, where the dispersion is low and range safety requirements can easily be satisfied, it becomes possible to conduct firings from the continental U. S. We have made several firings now from the eastern shore of Maryland, only a couple hours drive from our laboratory. We look forward to the day when 2 or 3 of us can simply leave in the morning with half a dozen instrumented rocket heads in our little stationwagon (which also serves as the telemetering receiving station), arrive on the proving ground, set up the launcher in a matter of a few minutes, put up the rockets and fire one instrumented head after another, collect our data, and drive home again after a good day's work. Things are almost at that stage now, and with further experience, rocket experiments may become so simple that they will not interfere with the other duties of a university graduate student.

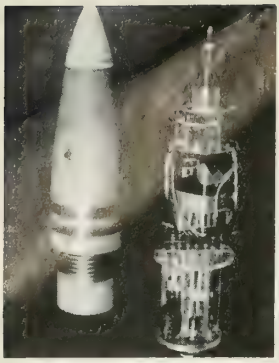
We are now in the beginning stages of a small-rocket upper atmosphere program, which will investigate many important high altitude phenomena; cosmic rays, solar radiation, micrometers, the earth's magnetic field, the day airglow and night airglow, the aurora, magnetic storms and others.

From this work master's and Ph.D. theses are beginning to flow. Typical publications by students include: "The design of an FM/AM transistorized telemetering system"; "The design of heat sinks for rocket telemetering instrumentation"; "Radiation equilibrium and temperatures of earth satellites."

Upper air research at a university often leads to basic progress in sounding rocket technology. For example, we have looked into a method of theoretically optimizing the design of a two-

It takes only three men to raise the completely assembled TERRAPIN into firing position. Pins in the launcher platform can be set into the earth to supplement the sand bags in holding the launcher firm. Pictures were taken during first TERRAPIN tests.





2.75-in. FFAR research payload. It takes some real doing to cram so much gear in so little space.



Though TERRAPIN was designed specifically as a research rocket, and FFAR is converted weapon, the latter is still a good research tool for Universities. And it costs only $50. Its disadvantage, however, is that it must be aerially launched.

stage rocket in the presence of atmospheric drag. This theoretical work has paid off in terms of a new design to project a five pound payload to over 1,000,000 feet, the vehicle as a whole weighing only 75 pounds.

When this vehicle is finally built we hope that it will be a truly low-cost University research rocket, one that will be simple and flexible enough to fit in comfortably with our unelaborate transportation and launching facilities. It must be kept in mind universities cannot justify the time and expense of setting up and maintaining a full scale test-missile launching base.

The simpler rocket scheme, however, makes the instrumentation job more difficult in terms of weight and space, but this emphasis has its advantages. It forces our students to consider the important aspects of an experiment and the telemetering instrumentation, and it forces us to compress the essential circuitry into the minimum space with the minimum weight.

We are approaching the day when the small rocket will be a commonplace research tool, as commonplace and (perhaps) even more useful than the rubber balloon which has been used in previous years to investigate the stratosphere. For the leaders of this research we must look to the men who are now receiving their training in this field as university students. ★

TERRAPIN in its launcher and ready to go. A major design objective was to cut preflight assembly and preparation time to a minimum.



TERRAPIN, named for the slow-moving turtle, streaks skyward at 3,800 mph and telemeters back research data during its 80-mile trip.





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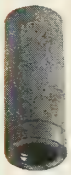
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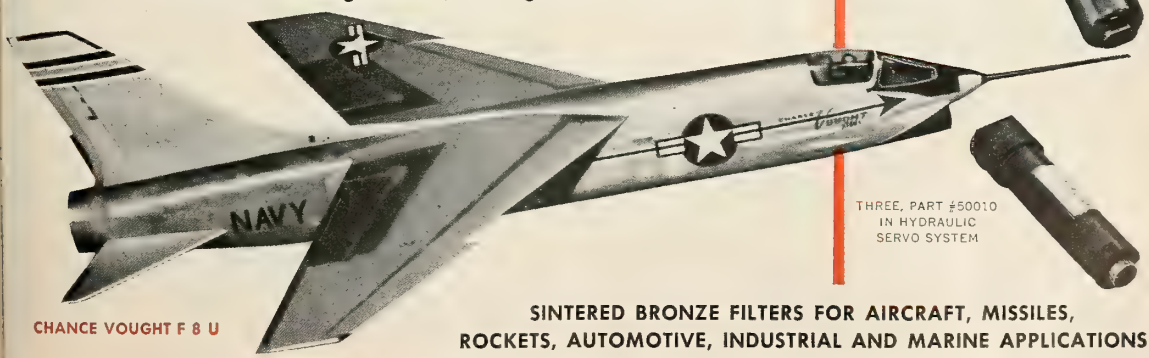
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Scientific Methods Replace "Fire-Fighting" Approach

By Henry P. Steier

MISSILE MANAGEMENT from design to combat use may some day be as scientific as mathematics.

Based on a numerical evaluation of certain missile program factors it is predicted this new science could do much to improve missile weapons system effectiveness.

These factors, according to E. H. Bender, Office of the Assistant Secretary of Defense (Engineering), Guided Missile Directorate, are: producibility, operability, reliability, maintainability, and performance capability.

In a talk before the recent National Symposium on Reliability and Quality Control in Electronics, Bender said best missile program management requires a trade-off of the relative values of these "abilities" during design, development, production and field test.

The derivation of measurement techniques for assigning numerical values to the abilities appears to be within reach but requires much improvement and refinement, Bender declared.

When they are available in the future, worthwhile savings in time, material, manpower and money are expected. End result would be earlier delivery of more effective guided missile systems to the armed forces.

The "fire fighting" approach used today to complete a missile system causes pronounced overlaps between program phases. Overlap occurs when design, development and prototype construction, etc. are done concurrently.

It is the aim of studies underway at OASD to remove the overlap and thus save time through the development of a more scientific approach by optimization of the controllable abilities.

Thus far work by OASD has shown reliability to be the area which would yield the greatest improvement in weapon system effectiveness. This is because of the existing low reliability level and high cost per missile.

For its purpose, OASD defined reliability as the inherent ability of electrical, electronic, and mechanical equipment is a weapon system to produce the planned operational effect while operated by military personnel.

When it undertook its missile management improvement program OASD set these goals for its work in the reliability area:

- Reduction in development time without telescoping of phases, or crash programs.
- Improved reliability level with reduction of workload on facilities and manpower.
- Reduced weapons system and evaluation costs.

Ground rules for the approach to these goals were based on five "convictions." The convictions established the questions and problem areas to which various groups of an adhoc committee were to direct their studies.

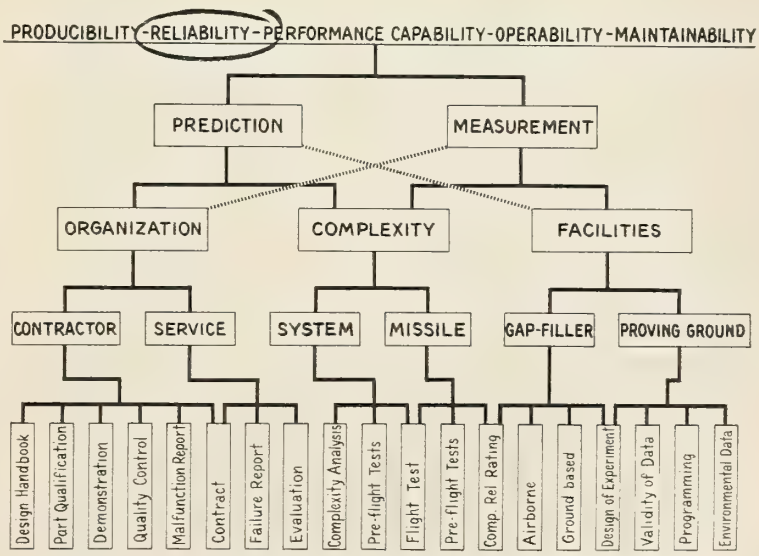
First, OASD believed reliability could be improved. Some people are pessimistic to the extent that they hold unreliability is a necessary evil. OASD reached its conclusion based on maturation of new techniques and observation of progress in other areas.

It is believed reliability should be a design parameter and should be specified and designed into equipment just as performance parameters are.

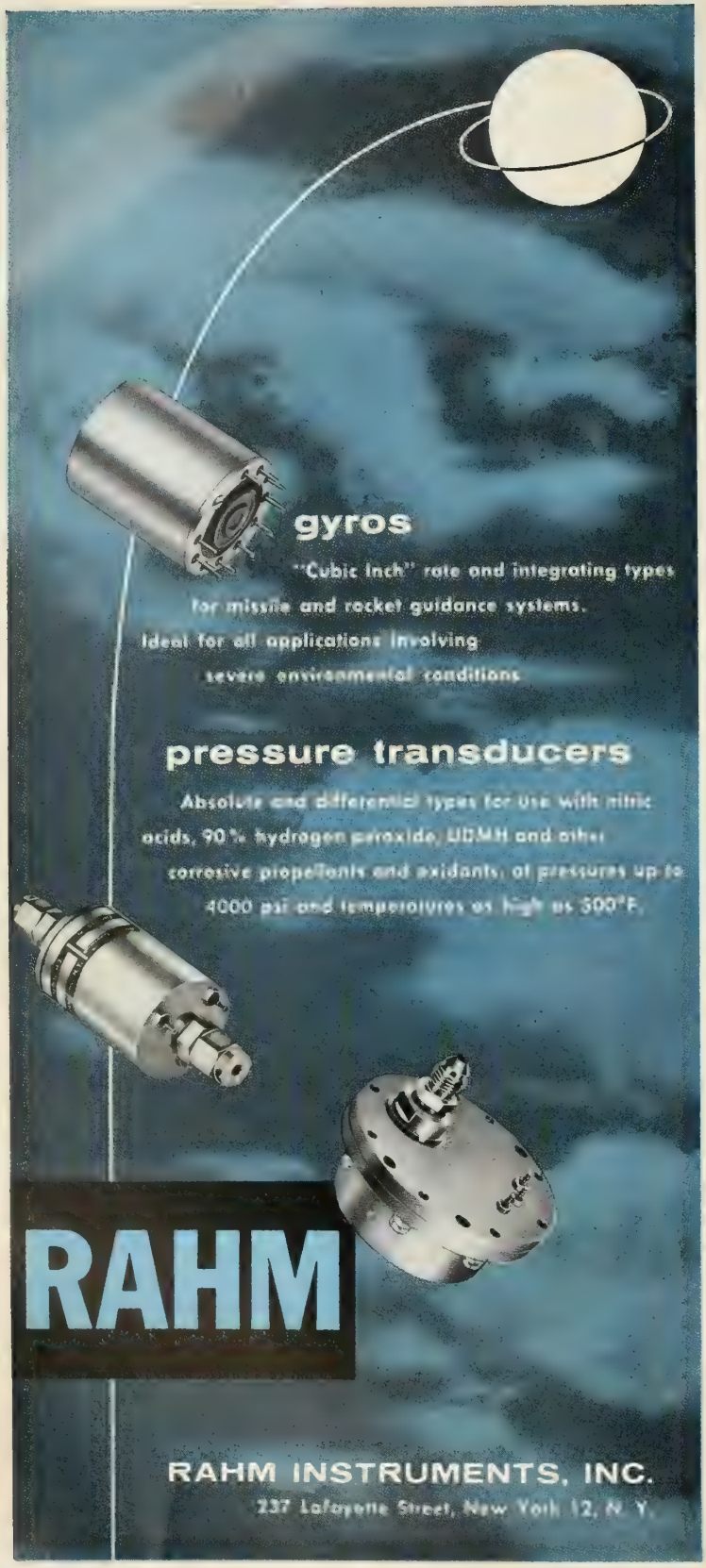
Accurate methods of predicting equipment reliability are needed and can be obtained. When they are, realistic procurement specifications can be written, and realistic weapons use planned. The basis for this prediction would be relationship between design, operating environment and reliability.

The committee felt shortened test cycles and improved validity and accuracy of information would accrue from scientific experimental design techniques. This would come mainly from use of simulators, high speed test tracks, flying test platforms, and restrained firings. These "gap fillers" would reduce missile test flight limitations imposed by cost and proving ground time available.

Lastly, the committee was convinced that present equipment specifications do not insure a satisfactory level of reliability over the intended service life of the missile system. Although accuracy and lethality are specified in almost all missile system contracts, these parameters are often demonstrated and then accepted on the basis of limited data based on impact or distance of burst from the targets.



Earlier delivery of more effective guided missile systems is expected if the "abilities" shown could be handled on a numerical measurement basis. Shown are relationships of factors under study by Defense Department to aid in developing reliability as such a management science.



Other system parameters may have been varied from realistic tactical conditions.

To establish recognition of individual problems among the different abilities under study, objectives were delineated and a problem structure organized as shown on preceding page.

Beginning with "prediction" and "measurement" in the case of reliability, OASD's initial effort was to move from an empirical measurement to an analytical prediction technique.

An area feeding into this prediction technique is "complexity." Initially the committee looked into the complexity versus reliability area. For this a working group used nine representative guided missile projects to get examples.

Examples needed were: methods of operation used in the three services; three main classes of missiles, air-to-air, surface-to-surface, surface-to-air; various stages of development and production for missile program maturity.

Also, key mechanical elements covering functional items such as hydraulic, propulsion and movable surfaces were tabulated.

From these data an evaluation of in-flight missile reliability versus electronic complexity was made. It showed a decrease in reliability with an increase in number of electronic parts.

Although the data showed a missile with 200 electronic parts has a reliability of about 83 percent against about 75 percent for one with 3,000 parts, this may actually represent a measure of missile program maturity rather than reliability, Bender said.

On mechanical complexity versus reliability, the OASD group has been unable to correlate complexity with missile program growth or missile environment. This may be because mechanical designs are more reliable or mechanical failures are easier to isolate and correct before flight.

Research in these matters is new and the committee is continuing its data collection work. Already, however, some benefits have come from the work. Bender reported that several large missile makers have reviewed and reorganized their reliability program as a result of these findings.

Full publication of a consolidated report on findings of the Department of Defense Advisory Group on Reliability of Electronic Equipment is expected early in 1957.

According to J. M. Bridges, Director of Electronics, OASD (Eng) publication of this report will represent the most complete and valuable analysis of the major phases of a reliability program ever compiled.

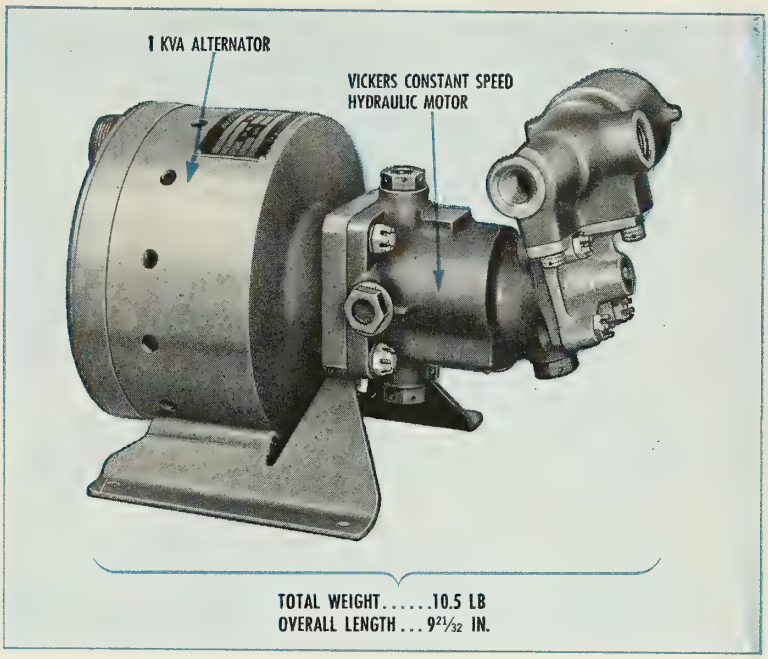
This should provide a basis for numerical analysis and control of reliability from design to delivery.

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New Vickers Airborne Electrical Power Package

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This new isolated electrical power package provides closely regulated AC power with minimum weight and envelope while drawing its power from a hydraulic system. In new designs or when adding electronic equipment to aircraft designs in which the electrical system is already loaded to capacity, this versatile package provides the needed AC power from flow available in the hydraulic system. This generally is permissible without system change as the full flow is seldom demanded except for a few seconds under rare circumstances. Even in such cases, full flow can be guaranteed to these hydraulic functions through the use of a simple priority valve which starves the AC power package momentarily.

Less Weight and More Efficient

Important weight savings are achieved through the use of this package instead of an inverter which may also require an increase in the DC generator and line capacities. In one instance, the 10.5 lb 1 kva package replaced a 38 lb inverter for co-pilot instrumentation. An additional advantage is that the package has 62% overall efficiency while that of the inverter was 35-40%.

Extreme altitude operation is no problem as the Vickers isolated electrical power package contains no brushes or other altitude-sensitive components.

Features of AC Generator

The permanent magnet type AC generator has excellent life and reliability. It requires no bulky voltage regulator . . . is inherently smaller and lighter than conventional generators due to the elimination of the exciter and slip rings. It also has higher overall efficiency resulting from elimination of all excitation losses. Additional advantages are that the permanent magnet is unaffected by momentary short circuit, or separation of field and armature without keeper, or by temperature cycling. It is also not susceptible to aging or shock. This unit is 120/208 volt, three phase, wye connected with 400 cps at 8000 rpm. It is capable of continuous duty under environments of 0-55,000 feet altitude and ambient temperatures from −65 F to 250 F.

Hydraulic Motor Drive

The generator is directly driven by a Vickers Constant Speed Hydraulic Motor having fixed stroke and an integral flow control valve that maintains an 8000 rpm speed setting within ±2½% regardless of the load (as long as valve inlet pressure is greater than load requirement). For the unit shown above, maximum operating pressure is 3000 psi while rated output of 1 kva requires operating pressure of 2200 psi. Special configurations will maintain 400 cps frequency within ±0.1% regardless of load. This motor has a very high horsepower-weight ratio and its overall efficiency exceeds 92%. It is a time-proved design capable of many hundreds of hours of continuous service without attention.

Many Uses and Sizes

The applications for this isolated power source are numerous. For multi-engine aircraft, its use for co-pilot instruments provides dual reliability. This package has been used to supply controlled frequency AC power in emergencies when the only source of power in the airplane is a ram air turbine driven pump. The efficiency of this arrangement minimizes the size and weight of the ram air turbine necessary to provide emergency hydraulic and electric power. 7492

Now available in the sizes listed below, larger packages can also be supplied from existing components. Vickers is prepared to develop the package best suited to a specific need. For further information, write for bulletin A-5213 or get in touch with your nearest Vickers Aircraft Application Engineer.

Vickers Airborne Electrical Power Packages

kva output	weight, pounds
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1.0	10.5
1.5	12.5
2.0	15
2.5	17
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CENTURY MODEL 409D RECORDING OSCILLOGRAPH

Numerous agencies engaged in the manufacture and evaluation of missiles have turned to the Century Model 409D Recording Oscillograph as a reliable means of collecting missile performance and control data.

On-board mounting eliminates the necessity for the costly and often not reliable RF link.

The ruggedness and reliability of this 12-channel oscillograph have been demonstrated many times. One agency reports having recovered 42 satisfactory record rolls out of 43 firings. Another, using special mounting configuration, reports recording at 60 G's without damage.

This 13 lb. instrument is compact enough to be installed in most missiles and all electrical connections including remote control are accomplished through a single multi-pin AN connector.

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Circle No. 28 on Subscriber Service Card.

Air Associates Renamed; Builds *Vanguard* Control Timing Computer

Air Associates, Inc. of Teterboro, N. J. has been reorganized under the new corporate name of Electronic Communications, Inc. and will shift its headquarters to a 75-acre site near St. Petersburg, Fla. later this year.

The name Air Associates will be retained, but only as the identity of an aviation supply division of ECI.

President Frank W. Godsey, Jr. said the new corporate name will reflect a redirection of the company's aims. As part of this program, Dr. Donald D. King, formerly of Johns Hopkins Radiation Laboratory has joined ECI and will head a new laboratory being built in Baltimore.

Dr. King and staff will direct their efforts toward electronic countermeasures research, fire control system studies, infrared work and related military electronics research of an advanced development nature.

The new emphasis on electronics is an outgrowth of past Air Associates activities at Orange, N. J., including the Navy *Vanguard* satellite pilot-computer, a device to be used for injecting the *Vanguard* into its orbit.



GODSEY

Electronics Communications, Inc. builds the coasting-time computer that will control timing of *Vanguard's* second stage jettisoning and ignition of the third stage.

The first computer will be delivered to the Martin Company in March and additional units will follow in line with the launching schedule.

Task of the computer is to gather flight data up through the second stage rocket's thrust period. From these data the device will compute correct coasting time between the end of this period and the operations which follow it.



Astrionics

By Henry P. Steier

Today has been called the "solid-state electronics era." In this issue of m/r Frederick Ordway notes what can be done with small research rockets. He says, "Today it is amazing what can be done with relatively low payloads of 25-50 pounds." It can also be said that the major portion of research rocket capability would not be where it is without the new science of—solid-state electronics.

The great amount of information today's rocketeer gets out of a very small instrumented rocket can be credited to the circuit engineer's early cognizance of the electric, magnetic and photic properties inherent in the new tiny, lightweight, low power consuming offspring of solid-state physics now taking the field. From talks and boosted attendance at the 1957 Transistor and Solid State Circuits Conference in Philadelphia last month came strong indication of early application.

Not so long ago the low input impedance and low voltage breakdown of semi-conductors was a real application hurdle. Engineers are finding a way out though. Now RCA has a bootstrapped collector emitter follower circuit that gives a 105-volt sweep generator signal. The follower has an unheard-of input impedance of 100 megohms. General Electric is using multi-holed ferrite core "transfluxors" as a means of digital to analog conversion. They are used as a combined memory ac gate and can be obtained from RCA at 50¢ each.

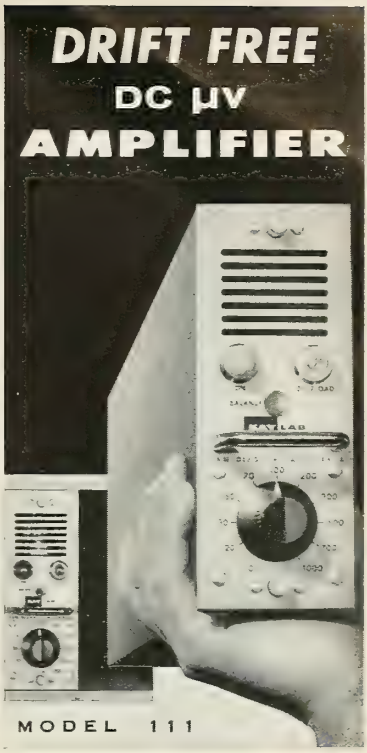
A counting circuit by Bell Telephone Labs. uses a ferroelectric capacitor that acts as a battery and switch in series. Depending on the capacitor charge the switch opens and closes. Two of the ferroelectrics in a particular circuit can simulate a "ladle and bucket" effect so that a count is not transferred until the second ferroelectric gets a given number of pulses. The device uses a barium titanate crystal and is in limited production by Hershel Chemical Co., Cleveland, Ohio. The IRE Professional Group on Circuit Theory proceedings covering the conference ought to give circuit engineers a lot for the money.

•

Western U.S. users of National Bureau of Standards for obtaining a calibration service of their instruments against national standards will get much better service in 1957. NBS is building a $2 million center at Boulder, Colo. to perform calibrations on instruments and components ranging from direct current to 40 kmc devices. Eventually a calibration service up to 100 kmc will be added.

•

Latest contribution to research missile data acquisition is RCA's AN/FPS-16 instrumentation radar. Availability of production units of the new system in December 1957 should improve instrumental accuracy by a factor of ten over available units and permit immediate reduction of data without manual operations or film processing. Space-time data will be obtained as direct digital read-out and be as good as, or better than, theodolite data. The FPS-16 is third of a series of radars for missile work by RCA. Others were the Bumblebee radar developed jointly by Johns Hopkins Lab. and RCA, and the Terrier radar for Army use of the Navy *Terrier* missile. RCA's prototype of the AN/FPS-16, the XN-2 will track *Vanguard* when it takes off.



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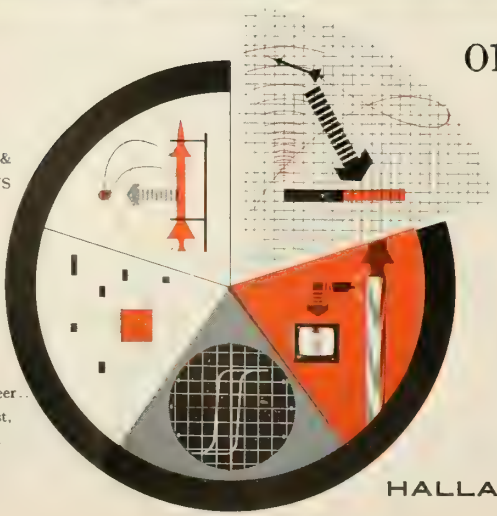
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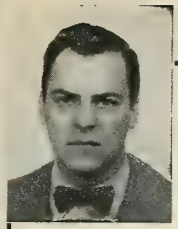
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Aerophysics

By Seabrook Hull

Confusion over what the Army's IRBM *Jupiter* did or did not do on firing day, March 1, at Patrick AFB may be explained by the fact that two were fired. Three missiles were supposed to have been tested. One is reported to have been a Northrop *Snark*. From a reliable source this column hears that the other two were *Jupiters*—that one left the atmosphere and was 60-to-70% successful before malfunctioning near the end of its firing period, that the other apparently tipped off course and had to be exploded not far from Delray, Fla., about 40 miles from Patrick. Neither was carrying operational guidance gear. In any case, members of ABMA's Redstone Arsenal team are highly gratified with the results and are busy readying the next *Jupiter* for test.

The ability to study the thermodynamics of hypersonic flow has received a terrific boost with the announcement of Dr. Gabriel Giannini's 10,000°K plasma jet and GE's MOSD's water stabilized arc that has officially achieved temperatures of 14,000°K and a heat transfer rate of 2000 BTU per square foot per second. Unofficially, this device is credited with a heat transfer rate of 6000 BTU. These rates exceed by wide margins ICBM requirements.

•

Dr. Edward Van Driest, NAA, participating in the space flight symposium emphasized the importance of design to reentry, whether by a satellite, space vehicle or ICBM warhead. The heat transfer rate through a turbulent boundary layer exceeds that through laminar flow by a factor of 10. Significantly, the advent of turbulent flow is delayed by cooling the nose cone. Van Driest also reported that boundary layer sensitivity to surface roughness apparently decreased with increasing Mach number.

In this same field, Dr. Fred Riddell, AVCO Research Laboratory, noted that in checking heat transfer theory against actual shock tube experiments, agreement between the two was good. He suggested that proper design precautions might enable the *Vanguard* satellite to survive reentry intact.

At Washington, D. C. Dr. J. H. Doolittle, Chairman of the National Committee for Aeronautics announced that NACA research rockets have "attained somewhat higher speeds" than the Mach 10.4 (6800 mph) revealed at last Fall's Langley Laboratory inspection. These new tests have, in fact, achieved 8000 mph. NACA is in the process of developing rocket techniques for in-flight study at between Mach 20 and Mach 30—up to 20,000 mph.

NACA this year is asking Congress for $41.5 million for new research facilities, 50% of which will be for hypersonic study equipment, including a hypersonic physics test plant to cost nearly $2 million.

•

An uniquely designed gyro-compass capable of rotational speeds up to 30,000 rpm utilizes a single airbearing instead of the six conventional ball bearings, detailed in Commerce Department's Office of Technical Service's report number PB 121405 translated from a 1954 German paper on Water and Air Bearings with Pressure Lubrication.

•

The area of contribution of the Vanguard Satellite during IGY will be confirmation and expansion of data from altitudes between 30 and 150 miles and the supply of entirely new data from 150 miles to possibly 1,500 miles.

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International Scene



By Anthony Vandyk

The British Army's first guided-missile regiment is being formed this month at Aldershot, the nation's traditional military base. Equipment for the new unit is the *Corporal* which is being procured in the U.S. Since the U.S. is not allowed to sell fission of fusion warheads nor to release any information about their design, the *Corporals* will be supplied to Britain without a warhead.

The next phase in the development of France's Trident fighter will be the elimination of the pilot. Remote control will be used to bring the pilotless rocket-powered aircraft back to base after it has launched its missile. The final stage in the "missilization" of the Trident is likely to be the transformation of the model into a VTO vehicle. The project is now being conducted by Sud Aviation which has been established to take over the operations of Ouest Aviation and Sud-Est Aviation. The Trident was developed by Ouest Aviation.

Cooperation between the British and French industries in the missile field is likely to increase very markedly. The French missile range in the Sahara desert could be made available to the British industry thereby cutting down the need for sending guided weapons all the way to Woomera in Australia for testing. Britain's coastal facilities are inadequate for all but the most elementary short-range launchings.

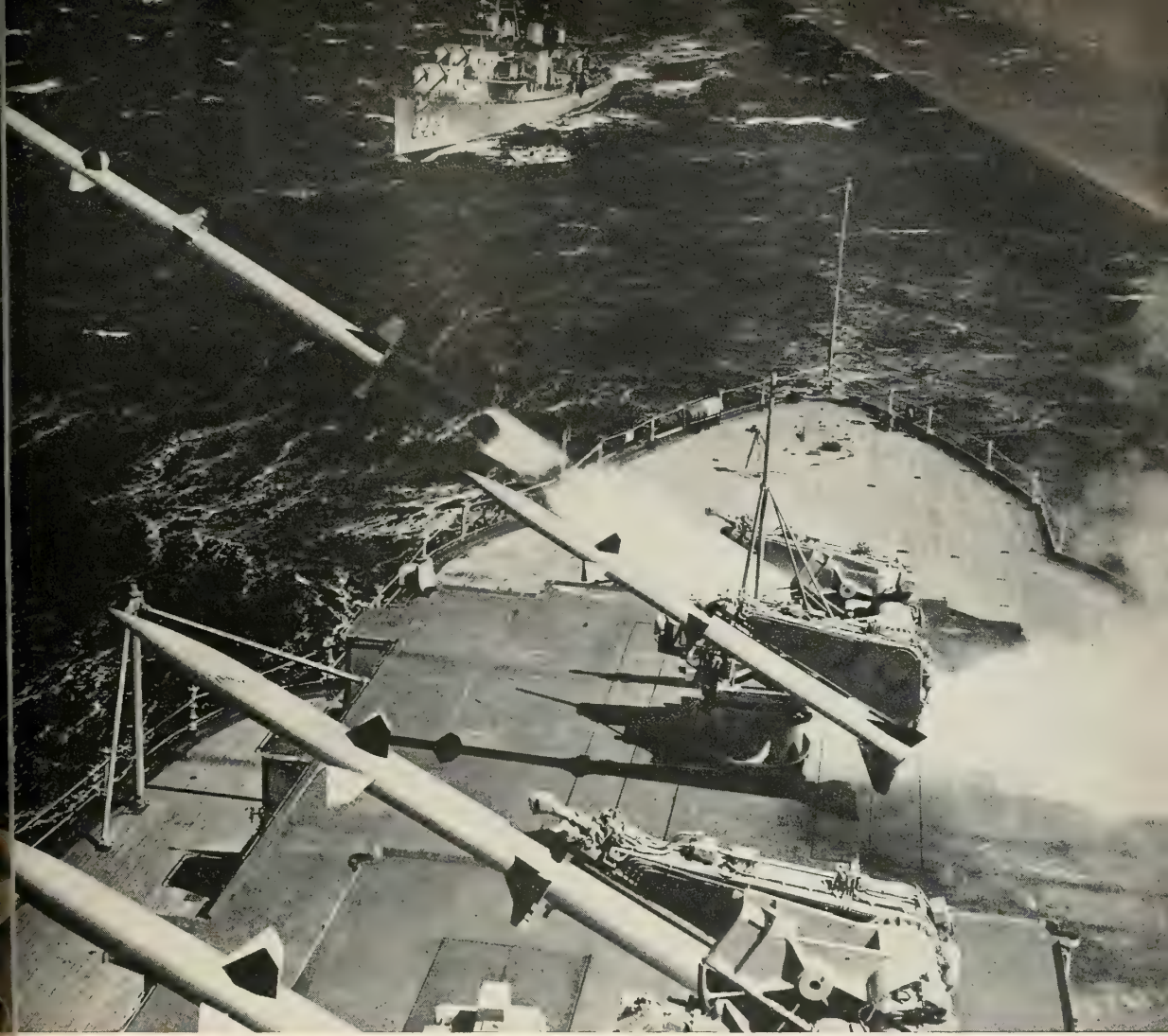
The Japanese government has requested the U.S. to supply seven types of missile: *Honest John, Nike, Terrier, Sparrow, Bomarc, Talos* and *Falcon*. It has not been made clear which of these guided weapons will in fact be supplied although the Department of Defense has agreed to let the Japanese have "certain unclassified equipment" including guided missiles for R&D purposes.

It's no secret that Sweden's only airframe manufacturer, Svenska Aeroplan AB, is very active in the missile field. It was recently disclosed that SAAB has been working on missiles since 1946 when the design of an "air torpedo" for the Swedish navy and the government's Board of Inventions was started. Another Swedish company, STAL, was also involved in this project which had its share of initial teething troubles. The first completely successful firing finally took place on June 3, 1947 at the Karlsborg experimental station on Lake Vaettern. The missile used a pulsejet engine developed by STAL.

There is high hope in Britain for the de Havilland heat-homing AAM which has been developed in conjunction with the Mullard electronics company. *The Economist* says: "After a period during which it was as easily distracted as a puppy, it has now grown into a well disciplined and reliable hunter." The British paper contends that the de Havilland missile "has an edge over its American counterparts."

Main contenders for French AAM production contracts are Matra and SNCA du Nord. The former company's position has been strengthened by the conclusion of an agreement of cooperation with the Floirat group which includes Breguet and RBV-RI. Breguet is a major airframe manufacturer while RBV-RI is an important electronics company. Both are headed by one of the most dynamic men in French aviation—Henri Ziegler, a former president of Air France.

That old bogey security is impeding European companies in their efforts to determine the market for their missiles. The British industry is able to furnish virtually no information to its NATO allies and to members of the British Commonwealth. The success of the British industry in the export market since WW II has been largely due to foreign sales of military models—mainly fighters. Unless the missile can take the place of the fighter, Britain's exports will suffer.



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Bristol Super Ramjet Makes Good

THE STORY OF the troubles and triumphs of the Bristol Aeroplane Company in evolving ramjet test vehicles has been released by the British manufacturer. To date Bristol has produced well over 200 *Thor* ramjet-powered test vehicles. They are rocket-boosted from standstill to speeds of over 1,000 mph in a few seconds during which time the *Thor* must light up and attain full power from a cold start. In this respect 100% reliability has been achieved.

The requirement was for a test vehicle with the following qualifications:

1—The ramjet was to be of flexible layout so that ready alterations could be made to the entry, burner, and to the tailpipe.

2—The telemetry transmitter had to be housed away from the ramjets where it would not be affected by vibration. The telemetry equipment had to be easily accessible.

3—Adequate space was to be allowed for installation of various fuel control systems for flight test.

4—It was important that the diameter of the ramjet did not exceed the maximum which could be bench tested over a wide altitude range.

These requirements were met by using twin 6-in. ramjets mounted outboard on each side of a center body in which the telemetry, fuel tank, fuel control and expulsion system were housed.

Fuel supply to the ramjets was effected by compressed air and controlled at a constant pressure by an air blast valve and a fuel pressure valve. The fuel was stored in a flexible bag situated in the tank forming the nose of the vehicle, and compressed air released from a pressure bottle in the front section of the center body, forced the fuel out of the bag along feed lines to the combustion chamber fuel jets.



Bristol fitted damping plates to the ramjets in one of its experimental test vehicles to raise the critical flutter speed well beyond that encountered in current operating range.

To accelerate the test vehicle up to the speed at which the ramjet engines begin to function, a cluster of cordite boost motors was used. One of the first problems which had to be faced was the separation of the exhausted boost motors from the vehicle without upsetting its flight path.

The first test vehicles had dummy ramjets and were fired to investigate the structure, stability and boost separation mechanism. Initial tests showed flutter and later, at Mach 1, instability which resulted in structural failure. Structural modifications were undertaken and a stable configuration was achieved. During these tests flight times had to be curtailed to five seconds owing to the limited size of the firing range.

As a result of the information gained from these dummy runs, Bristol produced a further redesigned version of the vehicle, influenced mainly by the major consideration of drag reduction.

By June 1950 the final design of the new vehicle had been completed, and drawing work for the launcher and loading trolleys was in progress.

The first flight of the redesigned test vehicle confirmed the accuracy of the theoretical drag estimates, showing a considerable reduction. By the end of September, two live rounds and five dummy rounds of the new vehicle had been fired, one of these being fitted with telemetry equipment. The first live round met with partial success—in both cases the ramjets fired, but were extinguished just before boost separation.

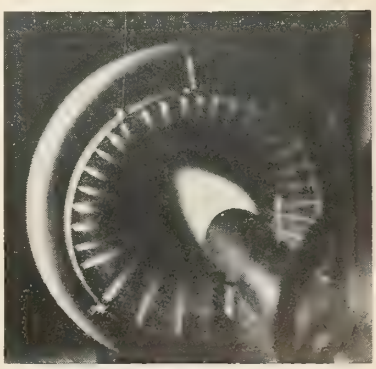
By the end of the year several more "hot" rounds had been fired to investigate light-up techniques. Some aerodynamic instability was experienced during the boost phase, but was cured by re-positioning the boost motors farther forward in relation to the vehicle. A redesigned separation gear was also adapted. This was an aerodynamically cleaner arrangement and allowed high speeds to be reached before separation of the boost motors.

During a continued study of light-up techniques, two short-range hot rounds were fired, and significant results were obtained from the second of these during the boost phase—one ramjet extinguished at about Mach 1 but the other continued burning until Mach 1.3 was reached, and telemetry readings indicated that it gave thrust. It was discovered that most of the trouble had been caused by interference to the airflow into the ramjets during boost separation. Telemetry recordings in "cold" ramjets showed a sudden drop in internal pressure at the time of separation, enough to cause the flame to be extinguished. As a result, it was decided to adopt a tandem boost configuration placed aft of the centre body, and between the ramjets.

However, success with the tandem boost brought on a new problem. More powerful boost motors were now being used, giving the vehicle an acceleration of over 20g and a velocity of 1,220 mph at separation. At this speed a completely new type of flutter was experienced. At that time flutter was known only on the wings and tail surfaces of an aircraft, but in the case of the ramjet test vehicle it was found that the greater fineness ratio of the body made possible a further type of flutter, in which the whole body was seen to flex at a fairly low frequency. The telemetry bay was therefore stiffened on all subsequent rounds and damping plates were attached to the ramjets. Theoretical investigation had shown that these measures would raise the critical flutter speed well beyond the operation range, and Mach numbers of 1.8 (1,350 mph) were later achieved without any recurrence of the trouble.

On July 19, 1951, the first objective of the program of ramjet development was reached. A short-range live round flew successfully. This success marked the first sustained supersonic flight to be made by a British designed and built ramjet powered missile.

By 1952 the test vehicle had served its purpose, and the program was brought to a conclusion. It reached the stage where it had provided a valuable means of flight testing and proving the components of a ramjet engine. ★



Much of the development program for Bristol's THOR ramjet was carried out with the aid of ground test rigs. Here water sprays quench the flame of a ramjet on test.



World Astronautics

By Frederick C. Durant III

Last year a symposium on the scientific uses of earth satellites was held at Ann Arbor, Michigan, under the auspices of the Upper Atmosphere Rocket Research Panel. Invitations were limited to authors from universities, government laboratories and selected research institutions. No press or contractors were invited. Thirty-one proposals for on-board instrumentation met initial screening requirements by the Technical Panel on the Earth Satellite Program and were referred to a working group in internal instrumentation for study and recommendation. This was much more than enough for the IGY program, which is still limited to six launchings.

Proposals were assessed on the basis of (1) scientific importance, (2) technical feasibility, (3) competence of source and (4) necessity to the proposed work of a satellite vehicle. The proposals covered ten specific subjects to be measured internally: UV and soft X-rays from sun, meteoric impacts, cosmic rays, cloud cover of earth, extreme solar UV radiation (500A), electron density of ionosphere, atmospheric density, geomagnetic field, auroral radiation, and galactic radiation. Priorities have been juggled in accordance with the scheduled development of instrumentation to meet environmental, power and weight requirements.

Press of time in preparing for the IGY satellite program, has prevented the Academy of Sciences from wider solicitation of suggestions for (1) kinds of satellite measurements, (2) measuring techniques to be used and (3) design of measuring equipment capable of meeting the extreme weight and dimensional limitations of the satellite payload. It may be that many important concepts and ideas have not been forthcoming because the basic problems themselves have not yet been brought to the attention of researchers here as well as abroad.

The IGY satellite program will be a single series of launchings. But most authorities expect this program will be followed by others, after the IGY has been concluded because of the demand by scientists for more extensive data obtainable in no other way. IGY satellite data will be limited and fragmentary. Some data will be in support of theory, other data will be paradoxical and unexplainable. Further, more extensive, measurements will be required.

Why not set up the mechanics and organize a long range program now, to be carried out under less pressure and with more thought than is possible for the IGY program? Such a program would appeal to those researchers who are repelled by deadlines. It would also offer an opportunity to tap the knowledge of brilliant scientists outside the United States. Research funds spent in such a way would be more efficient than in the current "crash" program.

From East Germany comes a report that a Soviet scientist is working on a preliminary design study for an unmanned, non-returnable reconnaissance rocket to orbit Venus. The planet would be TV-scanned and images transmitted to earth. The Venus "probe" would be launched from earth orbit of 22,000 miles. The rocket would be fueled by five "ferry" rockets (presumably manned) and make the trip to Venus orbit in 146 days.

•

Italy has nearly completed outfitting the cruiser, Garibaldi, with missile launchers in anticipation of operational surface-to-air missiles. Minister of Defense Taviani has also announced that Italian air-to-air missiles are being developed.

Space medical research is being undertaken by the Italian Ministry of Defense at the Research Center of Aeronautical Medicine. According to a recent report, test apparatus has been built to study subgravity conditions for short periods of time.

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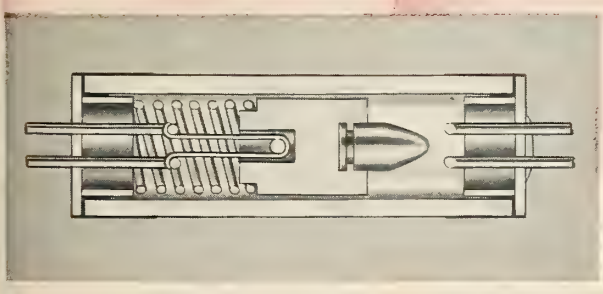
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How research rockets will tackle

The Conquest of the Moon

. . . and tell us what's on the other side

By Erik Bergaust

SEVERAL OF THE 10 ARDC centers are expected to synchronize their exploratory research activities shortly for the forthcoming USAF lunar rockets.

Although no decision has yet been made as to which moon rocket will come first, it is anticipated that it will be decided as soon as our ICBMs become ready for flight testing, i.e. within one year, and as soon as super-propellants and especially tailored control systems become available. Possibly two years later the first lunar rocket launching will be attempted. So one clear night, when weather conditions are perfect for the first firing, specimens of our intercontinental test missiles will zoom aloft from Patrick Air Force Base in Florida.

Under the impetus of its powerful, roaring rocket engines, the 80-90 foot missile will hurtle through the dense lower layers of the atmosphere. Some 30 miles up, the main stage of the rocket will have burned out and be jettisoned. A smaller bank of engines in the second stage will push the space vehicle on into interlunar space. Only a few minutes after blast-off the rocket will have reached escape velocity and in a matter of four days the vehicle will have made it to the moon, some 250,000 miles away.

The ambitious missile scientists behind the lunar rocket proposals feel the projects won't be too difficult to undertake. Of course, for centuries man's limited technology has ruled out "the trip to the moon" as something inconceivable, something for dreamers and storybook authors only. But not so today. Most scientists seem to agree the splitting of the atom actually was a far more difficult task than to send a rocket to the moon. Says one lunar rocket engineer: "The moon rocket is inevitable. There's not a question any longer of how to do it, but when. And this question has its answer in the availability of our ICBM engines."

"Even a redesigned *Vanguard* vehicle might have lunar capability," another rocket scientist says.

The gravity pull of the earth is significant enough to slow the rocket down on its way into space, but not sufficient to stop it. As the rocket approaches the moon, another gravity factor becomes involved, namely the pull of the moon itself. So the rocket will start to pick up speed again after having passed the "neutral" point where the gravity pull of the earth and that of the moon are in balance.

As the lunar vehicle comes in closer to the moon's surface and accelerates faster and faster toward Luna's mystic and majestic mountains, automatic devices will trigger the guidance and rocket power needed to adjust the missile's path into an orbit around the moon. While observers with powerful instruments on earth lose track of the missile as it disappears over the rim of the moon, instruments in the rocket's nose section will begin to scan the unseen side of the moon—an area as big as the North American continent, and an area never seen by man.

During the time the missile circumnavigates the moon, scientists on the earth will have no contact with it. But suddenly, it will be registered in the observing instruments as a tiny dot coming from behind and over the moon's rim on the opposite side. Then, at a precalculated moment, the engines will be fired again and the missile will leave the moon and return to earth.

The stored information will be telemetered to the ground station in Florida and the missile might be left in an orbit as a satellite. Eventually it will probably start descending into the denser atmosphere and evaporate like a meteor or it will disappear into space.

But the world's astronomers, geologists and other scientists will have obtained the most sought-after information of all time. But more important than just getting a look at the bashful side of the moon, enormous gains to science will be realized. These may include a very exact measurement of the velocity of light; determination of the

Ever since the days of the first Chinese "fire arrow" history has been sprinkled with stories on proposals for moon rockets. As revealed in our exclusive news story on page 25 we are getting close to realization of the first lunar vehicle. Here m/r details the why's and wherefore's, the significance and promise of the forthcoming Air Force venture.

residuum of an atmosphere on the moon; secondary radiation from the moon's far side; gravitational constants; microwave propagation; hydrogen clouds and drifting electrical fields.

Soviets Interested Too

But the Russians could beat us to the moon. Professor G. A. Chebotarev, a doctor of physics and mathematics and a senior scientific worker in the USSR Academy of Sciences' Institute of Theoretical Astronomy, made these observations in *Moscow News* recently:

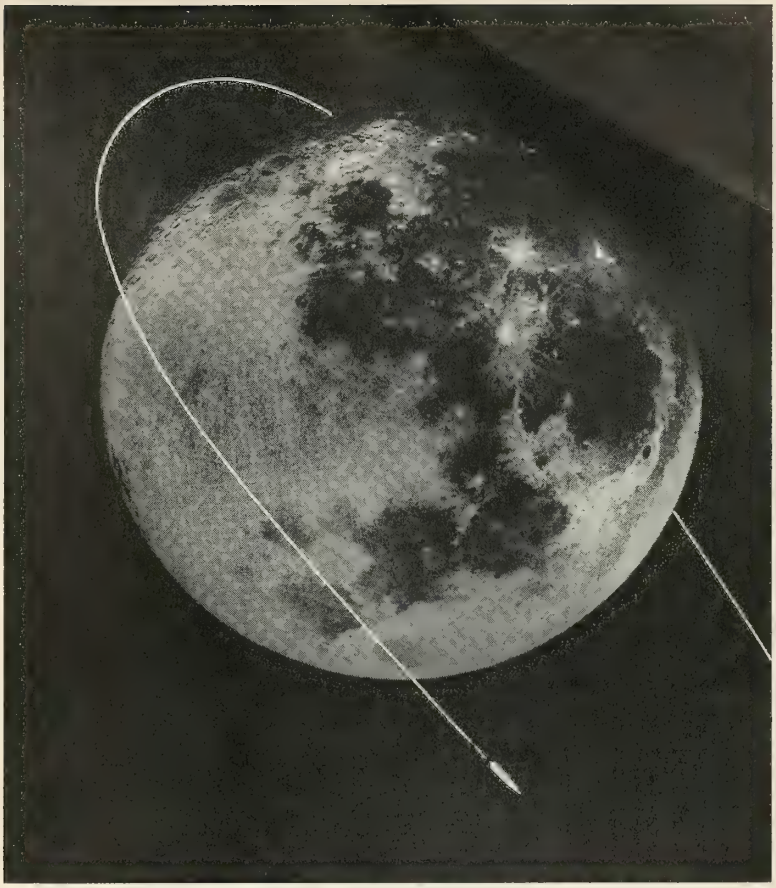
"Once the artificial satellites are created, the next step in the conquest of cosmic space will be to send 'automatic rockets' to the moon and the nearest planets in the solar system and to guide them back to the earth. Until now it was thought that such flights would require an enormous amount of fuel and that for this reason they would not be practicable at present. However, this is not so.

"The initial speed of such a rocket must be 6.8 miles per second. Near the moon this speed will drop to zero. This will make it possible for us to make observations of the side of the moon which is away from the earth. We shall be able to do this for about 60 hours with the help of various automatic devices which will be installed in the rocket," the Russian professor says.

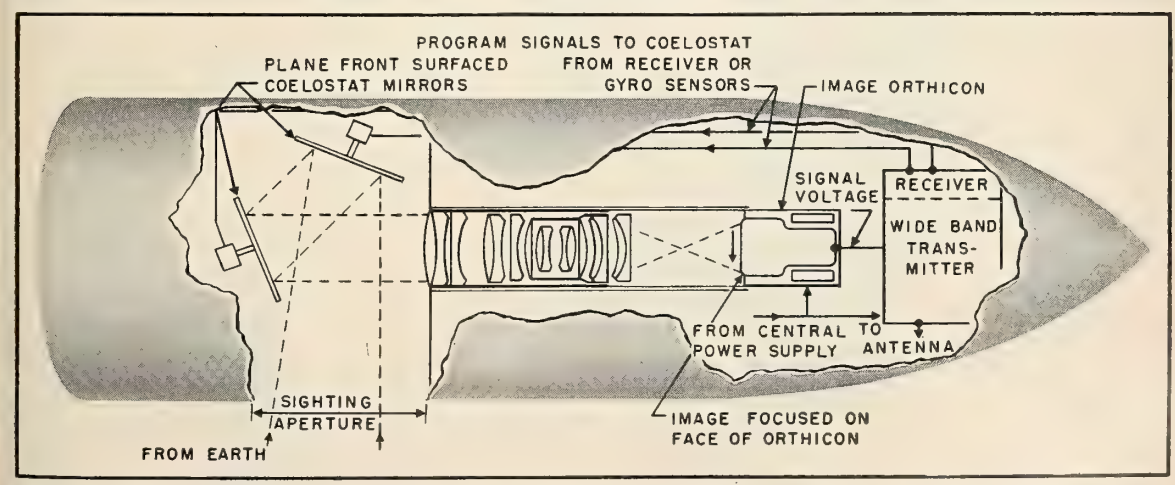
The Russians have calculated that the rocket will come within 17,932 miles of the moon. Its maximum distance from the earth will be 258,489 miles. The total duration of the flight from the earth to the moon and back will be 236.14 hours, about ten days.

At present orbits have been worked out which will allow the rocket to come within a distance of 3,100 to 3,700 miles from the moon, according to Russian scientists.

"During the rocket's return to our planet, its speed will increase once more to 6.8 miles per second. In order to retard the fall of the rocket, parachutes and gliders will be put out when it comes into the earth's atmosphere," says Professor Chebotarev. The Reds say this "new" discovery makes it pos-



According to Brigadier General Hollingsworth Gregory, man's first moon rocket may be a small instrumented vehicle designed to circumnavigate the moon and collect information of scientific value. Information on the unseen side of the satellite will be registered.



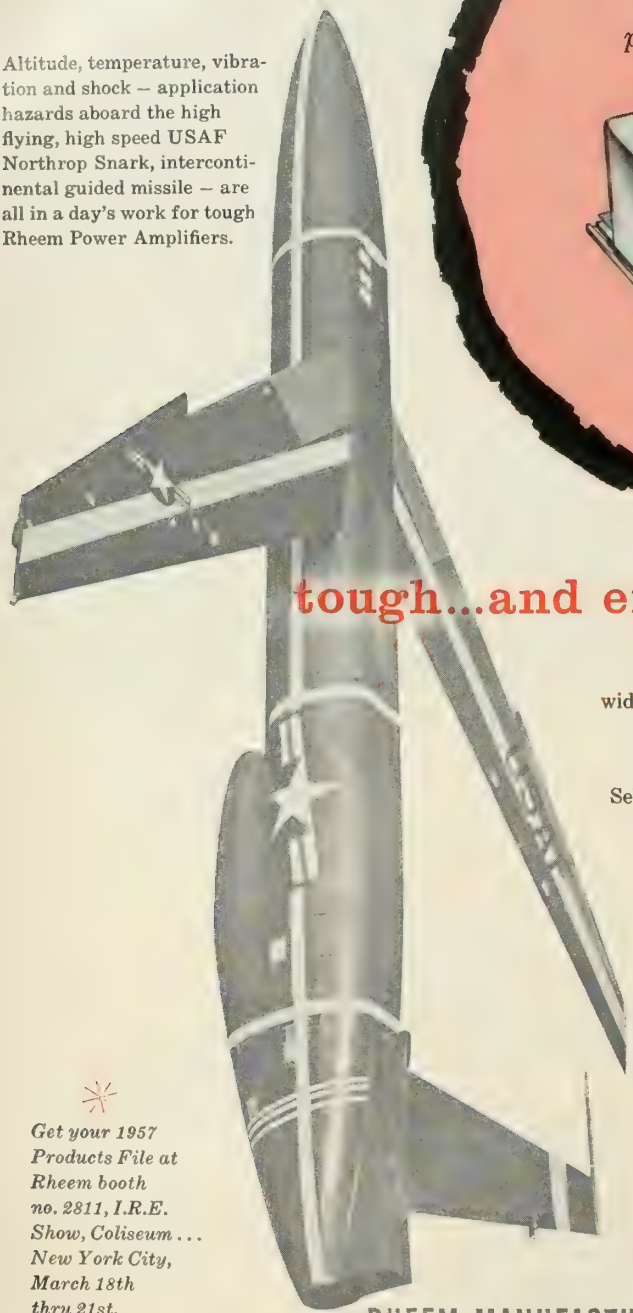
Variable focus Zoomar System television-type camera likely to be carried in the Air Force reconnaissance satellite. This video scanning system could give continuous photographs of 200,000 square-mile areas. Similar system might be employed in moon rocket. Mirrors reflect picture through telescope; orthicon unit converts picture into signals that are sent back to earth.

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sible to say that the solution of the problem of sending a rocket to the moon and bringing it back is of the same order of difficulty as that of creating an artificial satellite of the earth.

The Other Side of the Moon

Now, what *is* on the other side of the moon? And why is it that we never see it? Of course, our moon rotates around its own axis, as do all the other planets and their moons in our solar system. Our moon, however, is peculiar in its rotational behavior.

Walk around a circular table in the center of a room, and you will notice that upon completing the circuit you have at the same time turned around once. You have faced in turn all the pictures on the walls in the room, and to do so you are bound to turn around, to look at those which were exactly behind you when you started on your circular tour. In the same way, the moon is circling around our planet, always keeping the same face turned in its direction, while completing the orbit around the earth during the course of a month.

Because it is always keeping the same face turned towards us, we can never observe the moon's other side. This absence of rotation relative to us means that the earth must remain fixed in the lunar sky, never rising or setting. Owing to a slight "wobble" of the moon as it travels in its orbit, the earth would seem to move in a small circle around its average position, but this would hardly be noticeable, except at points near the visible edge of the earth's satellite.

Here there would be a narrow zone where the earth would bob up and down on the horizon—and beyond this belt there would be the region where our planet is forever invisible. For some reason this is often called the "dark side," but of course it would receive just as much sunlight as the rest of the moon—nor is there reason to presume that it will be very different in other ways, scientists believe.

Despite the seeming beauty of the moon, the Queen of Night has no light of her own. Her silver mantle is borrowed sunlight. The moon is a dead world—dusty, dry and airless—according to most astronomers.

"Silence of Death Must Prevail"

"There is not a sign of life, not a tree, a flower, or even a blade of grass to relieve the dreary monotony of boundless plains, mountain heights, or of yawning chasms," a scientist writes about the moon. Not a sound can be heard on its surface; speech will be utterly useless, as there is no air to carry the sound of a voice.

"The silence of death must prevail, the absence of air must also produce startling effects in a lunar landscape, distant mountains appearing sharply outlined against a sky black as at night, their outlines only brought into sharp relief when illumined at sunrise," says astronomer Mary Proctor.

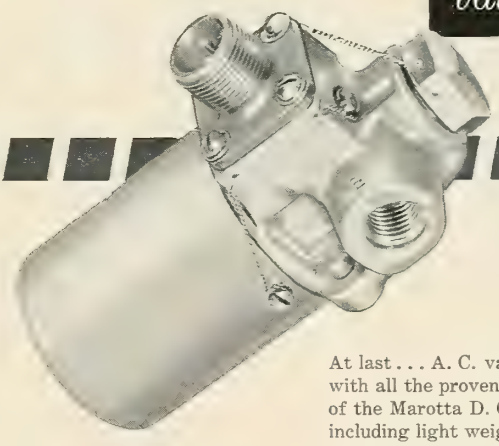
To the question "Is there life on the Moon?" most astronomers until quite recently would have returned an unequivocal "No," pointing out that the lack of air and the temperature extremes ruled out the possibility. Many astronomers still maintain this position, but a considerable number of experienced observers say they have detected changes in certain areas which suggest the existence of vegetation.

"It is by no means difficult to imagine that plant life might adapt itself to lunar conditions (some terrestrial cacti thrive in almost equally unpromising environments!) but for the present this must remain speculation," says astronomer Arthur C. Clarke.

There is no water on the moon's surface, nor the "seas" so fancifully named by Galileo, such as the Sea of Serenity, the Sea of Tranquility, the

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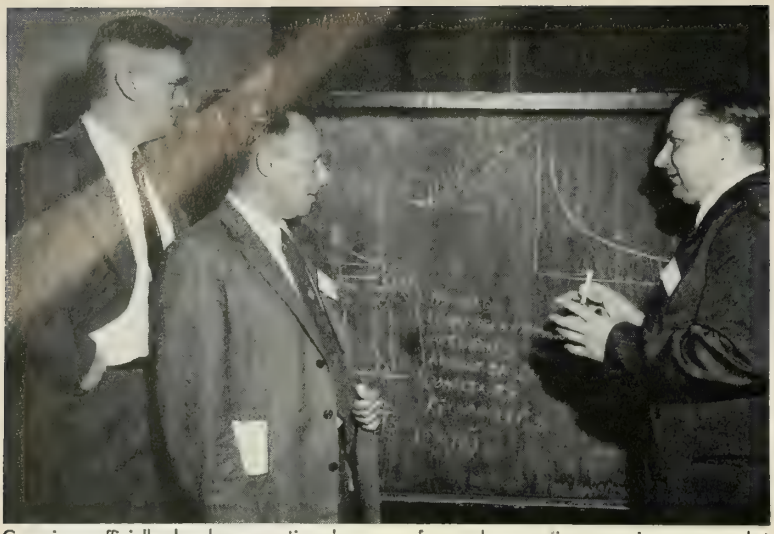
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Convair, unofficially, has been mentioned as one of several companies preparing moon rocket hardware proposals. This picture shows three Convair "moon rocket" experts. Left to right: Director of Scientific Research, DR. CHARLES CRITCHFIELD; Chief Engineer, K. J. BOSSART and Preliminary Design Chief KRAFFT A. EHRICKE.

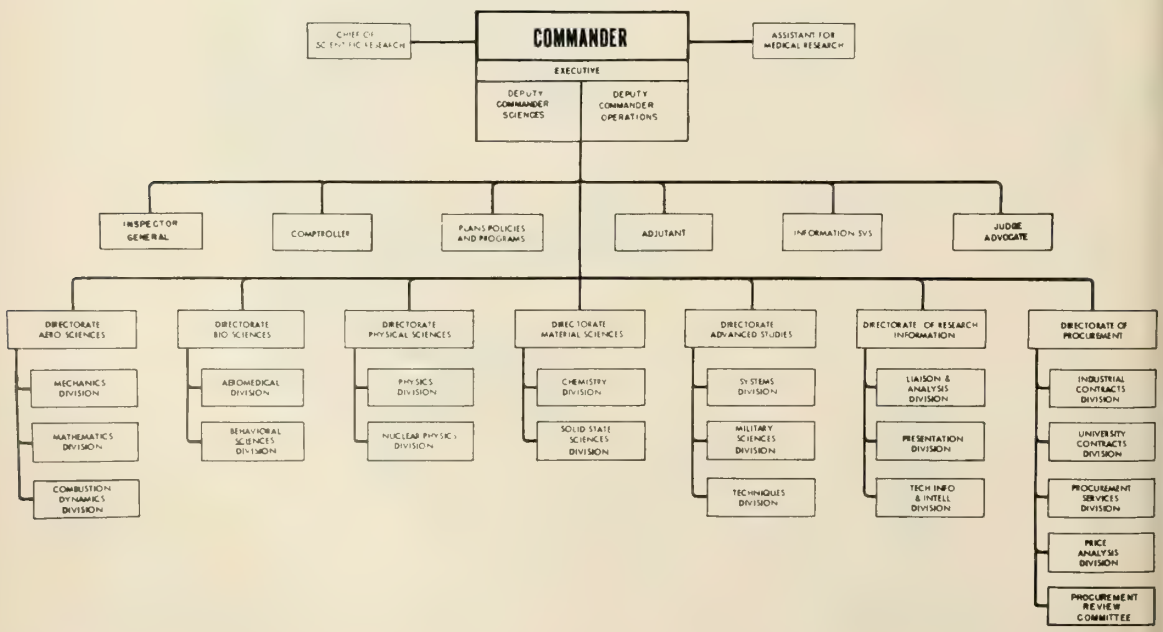
Bay of Rainbows, and others of like kind. However, these names are still retained on maps of the moon. Galileo named the greatest chain of lunar mountains after the Apennines, and this range on the moon borders on the Ocean of Storms. It extends some 460 miles, and is surmounted by a peak 21,000 feet high. Another mountain range named the Alps juts out from the Sea of Cold, and proves to be an exceedingly steep and lofty chain of mountains, one of its peaks called Mont Blanc reaching upward some 14,000 feet.

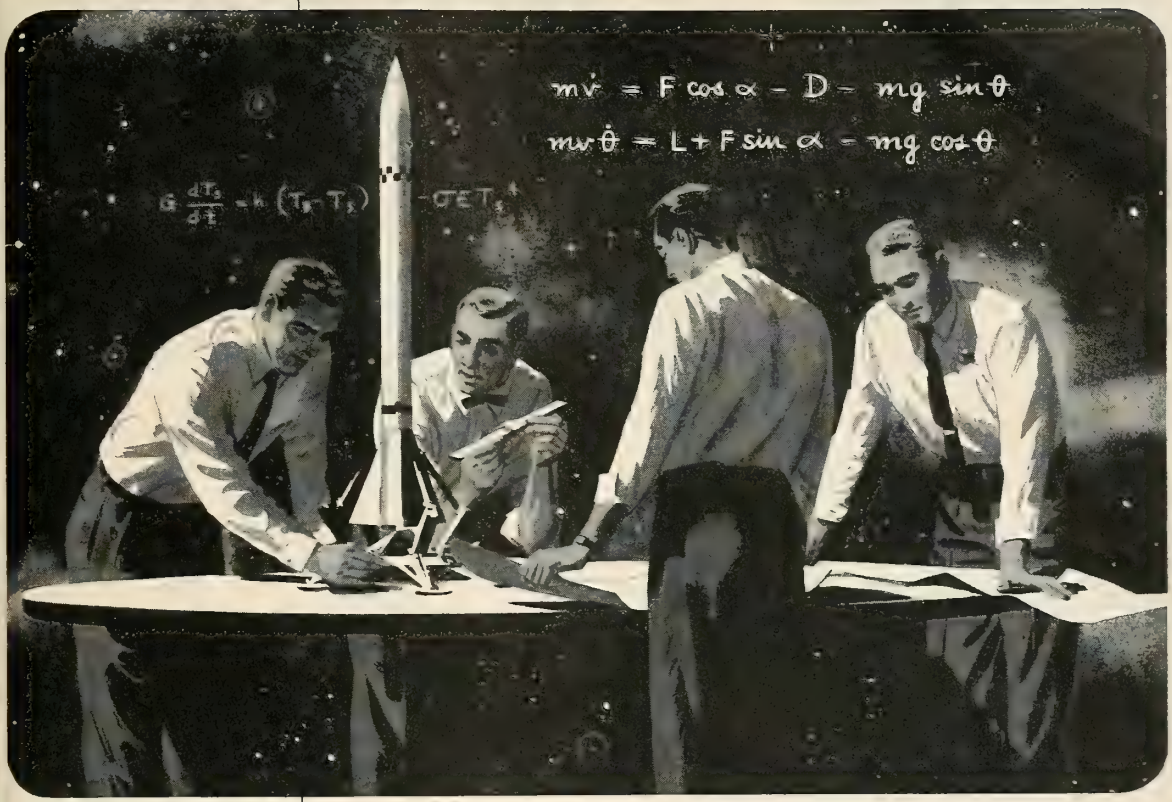
The height of many of the lunar mountains is equal to that of some of the highest on our planet. As the sun rises on the moon, the black shadows of these lofty peaks fall to a great distance as they creep across the plain below. As the sun approaches the point overhead, the shadows slowly decrease in length. At sunset on the moon the shadows fall in the opposite direction across the plains, until the mountain peaks only are illumined by the sun's light. The height of a lunar mountain or depth of a crater can be measured with considerable accuracy by means of its shadow.

Because of the moon's wobbling our researchers of the skies have been able to peek over the rim for some limited distance from time to time. What have they seen? Mountains, and more mountains. Most of them typical, ring-formed crater-type mountains, dark and cold, but impressive, spectacular.

Astronomers seem to think the rest of the moon's unseen side is filled with much of the same type terrain that can be seen from the earth. But we don't know. And since science cannot accept guesses or assumptions, since nothing but facts must prevail for our researchers in their effort to map the history of the universe we live in, tools for photographing the other side of the moon are most welcome. Only the United States Air Force can provide these tools; characteristically enough, the greatest of weapons, the intercontinental ballistic missile, will serve humanity in this research. It could happen as early as 1959, according to some engineers. By 1962 according to the Air Force's "conservative" estimate. But it *will* happen. ★

The Air Force Office of Scientific Research is in charge of the various moon rocket study contracts now being carried out. As the program progresses several other ARDC centers will become involved, particularly the Western Development Division.





Engineering Teamwork in Missile Development

The Jet Propulsion Laboratory is a stable reseach and development center located north of Pasadena in the foothills of the San Gabriel mountains. Covering an 80 acre area and employing 1700 people, it is close to attractive residential areas.

The Laboratory is staffed by the California Institute of Technology and develops its many projects in basic research under contract with the U.S. Government.

Opportunities open to qualified engineers of U.S. citizenship. Inquiries now invited.

Engineers and scientists interested in a wide range of activities will appreciate the fluid character of the research and development projects in progress at the Jet Propulsion Laboratory. These projects include research in the fields of Electronics, Physics, Applied Mathematics as well as the design, development and analysis of guided missile systems.

These men, though individually responsible, work together as a thoroughly integrated team on all of the aspects of the entire missile system instead of concentrating on certain highly specialized missile components.

Since this work includes projects involving guidance, electronics, systems analysis, structures, propulsion etc., which are constantly influenced by continuing Laboratory research, the comprehensive program contains problems which are challenging to individuals with interests in virtually every phase of engineering and science.

The great diversity of activity and constant progress being made in the various fields of endeavor by the staff of the Jet Propulsion Laboratory has proved to be a stimulating attraction to qualified people interested in pioneering in basic research, applied research and development engineering in the guided missile field. The result of this has been to bring together a congenial group of forward-looking engineers and scientists who are intensely interested in the pioneering projects now in progress at the Laboratory.

Additional men of this type are needed and if you are interested and feel you are qualified, send your resume today for immediate consideration.

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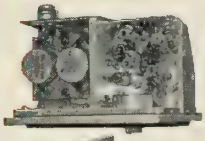
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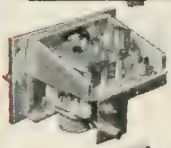
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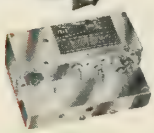
Direct FM Transmitters Crystal controlled 215-235 megacycles. 125kc deviation.



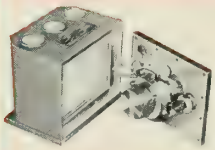
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Model 1463—5 19/32″ x
3 13/16″ x 4″
15 to 30 Watts



Model 1472—4″ x 1.5″
x 2.7″
2 Watts

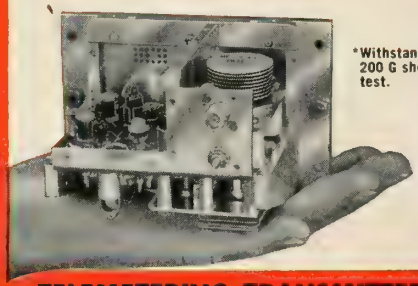


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Tactical Reliability—the Main Test

Combat Performance Determines Missile Quality

By Captain Patrick W. Powers, U. S. Army

AT A RECENT guided missile reliability symposium, a participant stated that a certain missile system had 14 out of 15 successful firings. Thus, it was 93% reliable, which is commendable indeed! However, judging from the murmurs of dissent from the audience, largely military, it was evident that his definition of success was not in agreement with that of the majority.

The usefulness of a missile as a weapon depends not only on its performance once it's launched but also on whether it gets unstuck at the precise time required by the military situation. Test range reliability is one thing; tactical reliability is quite another and the one, after all, that really counts.

There is a real need for a valid definition of tactical reliability expressed in explicit terms of weapon use. Reliability percentages without regard to operational firing conditions and functions don't give an adequate idea of a missile's usefulness as a weapon. Research and development firings are so different from military usage that figures are misleading.

The product of the reliabilities of critical components in a missile system is useless to the military commander in the field. He defines tactical reliability as the probability that a missile system will detonate the warhead at an effective distance from the target when he wants it—not at some random future time.

Often when discussing missile reliability we lose sight of the only military requirement for a guided missile: to get an effective warhead on target on time. The relationship between the warhead and the missile becomes, then, of critical importance and must be included in any concept of reliability.

Where the warhead detonates is broken down into a three-dimensional problem. A height of burst bracket is determined by the fuzing system and a range and azimuth error by the guidance system. The actual accuracy requirement depends on the effect desired on the target to be attacked and on the type and size of the warhead used. For some surface-to-air missiles, the guidance and fuzing systems may be combined but there remains a maximum three-dimensional miss distance outside of which the warhead will not be effective on an attacking aircraft.

A likely target for a surface-to-surface missile might be a large body of troops concentrating for a river crossing. The mission of the missile attack might be to render 50% of this mass of soldiers combat ineffective for a period of eight hours. To accomplish his mission, the commander would determine from his firing tables and warhead effects manuals the height of burst bracket and maximum miss distance to insure the proper effect on the target. Depending on the tactical reliability of the missile system and its accuracy, he might have to prepare one or more to accomplish the mission.

The accuracy or miss distance of successful missiles can be stated as a circular probable error or median radial miss distance with a maximum miss distance to include 95% of all missiles fired in the sample used. This approach will then more precisely define what is meant by a successful firing for testing and training purposes and give the commander reasonable accuracy limits on which to base his decisions for combat firings. For tactical purposes, an arbitrary miss distance is n ot valid since it would depend on the effect desired for a given target.

With a large and continuous personnel turnover, expert crews seldom



Martin Matador. It's a weapon and it's reliable only if it delivers its warhead where and when the field commander requires. In a combat situation, there is no second chance.

Trial Number	Preflight Successful	Inflight Successful	Remarks
1	No	No	Not fired; late
2	Yes	No	Fired; excessive miss distance
3	Yes	Yes	
4	Yes	Yes	
5	Yes	Yes	
6	No	No	Not fired; late
7	No	No	Not fired; late
8	Yes	Yes	Fired; third attempt
9	Yes	Yes	
10	Yes	Yes	

- *Actual Missiles Fired—7*
- *Preflight Reliability (7/10)—70%*
- *Inflight Reliability (6/10)—60%*
- *Tactical Reliability (6/10)—60%*

can be realized for an appreciable length of time. This requires reliable, soldier-usable equipment that can be operated under severe conditions.

Only combat experience will provide valid figures. A hypothetical example of the inflight reliability of a ballistic missile system based on these types of firings might be the following: success criteria—armed within 2000 meters of target; total missiles fired—10; successful missiles—6; inflight reliability—60%; accuracy—with a median radial miss distance of 800 meters and a maximum radial miss distance of 4000 meters.

Preflight Reliability

To meet a firing time, the missile system must have a high checkout or preflight reliability. Time is always of the essence in a tactical situation. The rejection rate of components that malfunction must be at a minimum so that combat firing deadlines can be met. Repair parts must be carried to replace defective components. Since only a limited amount of spares can be on hand, the checkout reliability must be high. Once the missile and associated equipment have been checked out, there may be a long wait period while system components are warmed up and turned off several times.

For air defense weapons and long range missiles, this cycling may occur for months and probably years, thus emphasizing the fact that these components must have a long life even if the missile is a "one shot" weapon.

Meeting a firing time also depends on the maintenance of complex electronic and mechanical equipment. This involves both training problems and a built-in system of maintenance. This perhaps can best be met by module packaging with a means for quickly isolating and replacing a defective unit. Maintenance support through various echelons of maintenance must assure field commanders that the firing organization will get parts and repairs for major items of equipment in an expedited fashion.

The key to the reliability of the military operators is a set of valid, troop-tested operating procedures. The commander hopes there will be no deviations from these procedures. However, the continuous equipment changes and modifications to a system after it is put into operational use makes this impossible. The responsibility for getting changes through to the field begins with the developing agency and extends down through the military channels to the operator.

If the missile system cannot detonate the warhead at an effective distance from the target at the proper time, then the tactical reliability is zero for that mission just as surely as if the target were missed by an excessive distance. For military training and contractor test firings, this time factor must be established and an unsuccessful trial charged against the system when it fails to meet the required time. Thus, a missile may eventually be fired successfully although previously charged with several unsuccessful trials because it failed to meet specified times.

Using the same ballistic missile system as in the previous example with a 30-minute time bracket specified as a trial, the three reliabilities might result as shown in the table above. Note that this missile system failed to make the firing times in trials 1, 6, and 7.

Maintaining and Improving Systems Reliability

Once a missile system has been issued to the field, the commander must be assured that tactical reliability will be maintained and improved. This reliability is a function of the reliability of the critical components of the entire missile system and of the reliability of the military operators. Without such recognition of these critical reliability factors, the finest research and development missile system will never become a successful tactical weapon.

Continued training by mock and live shoots must be emphasized. Units stationed away from one of the few missile ranges in the U.S. seldom get to fire their weapons. When they do fire, they can expand only a few missiles. This makes maintenance of a high level of proficiency very difficult. There is no substitute for actually using a weapon whether it is a rifle, an airplane, or a guided missile.

Consequently, the field commander must turn to mock firings, simulators, and technical assistance teams composed of experienced combat-arms soldiers to accomplish his task. The tactical reliability of a guided missile system and a military crew on the alert for months will indeed be low if an intense program is not followed to keep the state of readiness and training up to a high pitch.

A current analysis of firings must constantly be made to improve the missile system. Military training firings can be utilized for this if telemetry is used. In fact, telemetry should be used if possible for all tactical firings as a feedback of vital information to isolate malfunctions that otherwise never would be known. The developing agency must be on the alert to quickly solve technical problems that appear with tactical use.

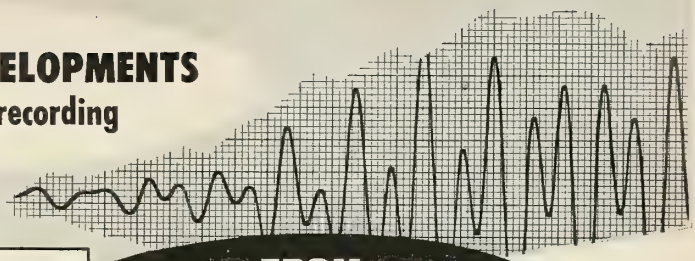
The most efficient means of managing the complex guided missile system from the contractor to the field is centralized technical control under the direction of a single office. Integrating missile channels of supply, maintenance, and information with conventional weapons does not solve the unique problems that have their roots in the firing organization. Remedial action must be immediate if readiness is to be maintained.

Summary

If the symposium participant mentioned earlier had stated that his missile system had detonated the warhead at an effective distance from the target within a specified time for 14 out of 15 trials under simulated military-tactical conditions, the cheers of the audience still would be ringing in his ears. This would have meant that our guided missile program had arrived at the threshold of absolute tactical reliability.

The results of military training and contractor test firings will be much more valid using such concepts of preflight and inflight reliability. In fact, the only way to compare and evaluate the reliability of different missile systems is to use a standard method of determining reliability based on the intended use of the weapon. ★

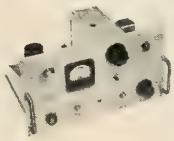
TECHNIQUES and DEVELOPMENTS
in oscillographic recording



FROM
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PHASE SENSITIVE DEMODULATOR PREAMPLIFIER PROVIDES A DC VOLTAGE PROPORTIONAL TO AN INPHASE COMPONENT OF AN AC VOLTAGE WITH RESPECT TO A REFERENCE.

THE measurement of the amplitude of an AC voltage component is often necessary in performance studies of servo systems or of suppressed carrier signals over the carrier frequency range from 60 to 10,000 cps. In such cases the demodulator responds to inphase signals and rejects quadrature signals.



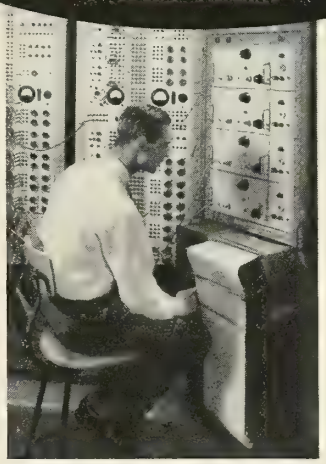
A circuit with these characteristics for use in an oscillographic recording system can be seen in the Model 150-1200 Servo Monitor (Demodulator) Preamplifier. It was developed by Sanborn as one of twelve interchangeable, plug-in front ends for "150" Series equipment, to be used with the appropriate Driver Amplifier-Power unit in any channel of a "150" system. Elements comprising the circuit from input to output, include: compensated stepped attenuator and cathode follower input circuit, phase inverter, push-pull mixer and demodulator stages, differential DC output amplifier and low pass filter. In addition, the chassis contains a VTVM to facilitate accurate adjustment of the reference voltage, and an overload indicator which lights a warning lamp when excessive quadrature voltages exist.

Adaptability to a fairly wide variety of applications is accomplished through broad input voltage, reference voltage and frequency ranges. In order, these are 50 mv to 50 v (for full scale 5 cm deflection), 10 v to 125 v; 60 cps to 10kc. Rise time with low frequency plug-in demodulation filter is 0.1 seconds; with high frequency filter, 0.01 seconds. Quadrature rejection is better than 100.1; for carrier frequencies up to 5000 cycles.

Two representative uses of the Servo Monitor Preamplifier are in the design and adjustment of servo systems, and with instruments used in the design, development or adjustment of other apparatus. The first is illustrated by use of the Preamplifier and associated equipment in the recording of the output shaft amplitude and driving frequency of an AC positional servo; the second by recordings made with a similar setup of the difference between output signals from a gyroscopically-controlled stabilizing device and the "pitch" and "roll" signals generated by a "Scorsby Table" used for testing the device under dynamic conditions.

For a detailed discussion of the principles and design considerations involved in the Servo Monitor Preamplifier, refer to the February, 1955 issue of the Sanborn RIGHT ANGLE, for Dr. Arthur Miller's article on "Measurements with the Servo Monitor Preamplifier."

Technical literature and engineering assistance on specific problems are always available from our engineering department.



BASIC FACTORS IN SELECTING OSCILLOGRAPHIC RECORDING EQUIPMENT

WHEN considering any oscillographic system or equipment for your application, three useful "yardsticks" to apply are (1) the recording method, (2) equipment adaptability, and (3) variety of equipment available. Here are the answers to the three, as they apply to Sanborn systems. In the record, rectangular coordinates accurately correlate multiple traces, simplify interpretation and eliminate errors. Permanent traces, produced by a hot ribbon stylus without ink, provide sharp peaks and notches, and clearly reveal all signal changes. One percent linearity results from current feedback driver amplifiers and high torque galvanometers of new design; maximum error is ¼ mm in middle 4 cm of chart, ½ mm across entire chart. From the standpoints of "adaptability" and "variety", Sanborn "150" equipment offers the versatility of 13 different plug-in front ends for any basic system . . . the choice of one- to eight-channel systems . . . the variety of nine chart speeds, timing and coding controls, console or individual unit packaging . . . availability of equipment as either complete systems or individual amplifier or recorder units.



The purpose of the foregoing information is to better acquaint industry with typical oscillographic recording problems and their answers, design considerations in Sanborn equipment, and basic data on what Sanborn makes and how it is being used.

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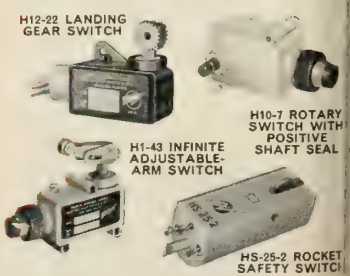


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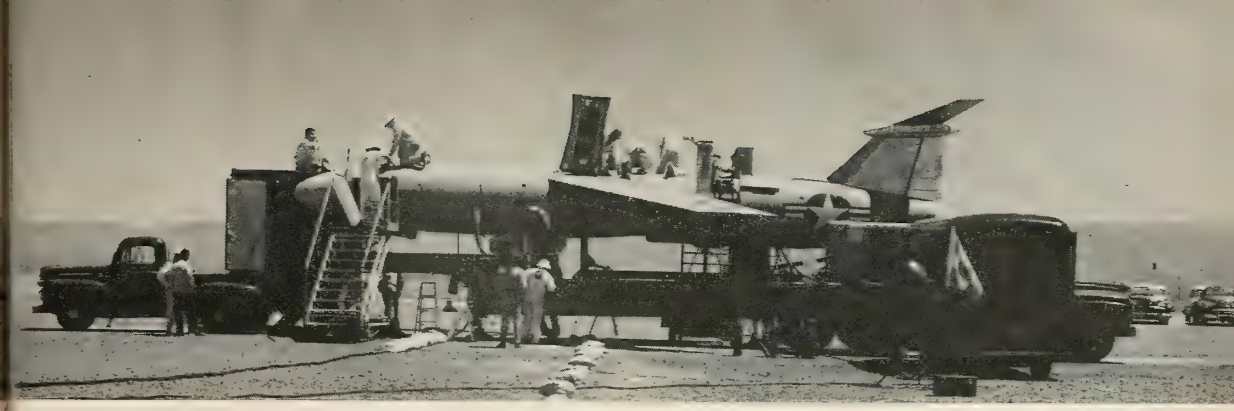
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Million - to - One Shot

Reliability Engineering—A New Science to Cut Missile Misses to One-in-Twenty

By William Shepard West
The Martin Company

TO THE ARMED services the proof of a guided missile is in its reliability. A missile is a brilliant weapon, but only when it proceeds to target upon receipt of the first command to launch. There is no second chance.

Military insistence on bug-free missiles finds emphatic expression in a contractual clause that quality control experts soon learn by heart. The clause commits the manufacturer to a reliability standard of, say, 95 per cent. His acceptance is a flat guarantee that when 100 of his missiles are fired, fewer than five will turn out to be duds. The remaining 95 must impact in the target area.

The 95 per cent standard is such a large order that odds of a million to one have been quoted against its achievement. The reliability engineer faces an engineering frontier newly born of military necessity. Outsiders have only a loose understanding of what he is up against. An attempt is made here to explain the reliability engineer's job and to suggest the magnitude of his responsibility.

Most of us started thinking of associated reliability concepts before we were in high school, linking them with dependability. The old college football team was reliable; it could always be counted on to "hold that line." Our first car was reliable; we knew it always would start by the time it had coasted down the hill. Our dog is reliable; she always barks when someone rings the doorbell.

Numbers and Reliability

Let us consider the dog and the doorbell through 10 days in terms of the simplest mathematics associated with reliability. Assume the doorbell is operated 10 times each day for a total of 100 operations. If the dog barks only when the bell operates, we would expect her to bark 100 times in this period. Let us assume that once each day she happens to be asleep when the bell rings, and when she sleeps she doesn't bark. The probability that she will bark when the bell rings, therefore, is 9 out of 10 each day, or 90 per cent of the time.

Suppose that we have five such dogs, each sleeping at random times, and that the doorbell also is operated on a random basis. What is the likelihood that all of the dogs would bark each time the bell rings? Only 60 per cent of the time, by the same simple probability—0.9 x 0.9 x 0.9 x 0.9 x 0.9=0.59. We have assumed that since the dogs do not hear the doorbell when they sleep, they will not hear the other dogs barking.

Briefly restated for the dog-doorbell situation, the problem area is this: a system employing only five items, each of which is 90 per cent reliable, will produce an over-all system reliability of only 60 per cent.

Extending this elementary concept gives rise to some surprising numbers. Consider a hypothetical missile system that has an electronic transmitter, command giver, and a missile—three subdivisions. The transmitter comprises at least a hundred items—wires, resistors, capacitors, tubes, soldered connections. Now if each of these hundred items is 99 per cent reliable, we figure that the over-all reliability of the set is $(0.99)^{100}$, or about 36.3 per cent.

Now it is common knowledge that radios are more than 36 per cent reliable. So the inference is plain that each component in your radio, operating in the environmental condition of your home, with circuits and components of conservative design, performs at a reliability rate higher than 99 per cent. The more highly powered transmitter, with its hundred or more items, works under a greater handicap than does the home set, making achievement of 99 per cent reliability of components somewhat more of a problem.

Environment and Design Objective

The minimum environmental conditions that virtually all systems must be able to withstand are set forth indirectly in the test procedures of military specifications, which imply temperatures from -65 to 160°F, altitudes from sea level to 50,000 feet,

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various conditions of vibration, shock and acceleration, etc. The detail specification and the tactical use of weapon systems often exceed the requirements.

Accordingly, the demand on components is vastly more rigorous in tactical use than under typical laboratory or home conditions. Something that works well on a living room table may be inadequate in the deep freeze.

Another difference is the requirement for small size and light weight—a must in military missile applications, but sometimes a sign of cheapness in the home radio. In sum, the rigors of tactical weapon system environments obviously do nothing to encourage the highly dependable operation that the design objectives demand.

More Wood for the Fire

Referring back to the hypothetical missile system, we see that if the transmitter has 100 components, each of which is 99 per cent reliable, the transmitter is about 40 per cent reliable. No doubt, the other two subdivisions—the command giver and the missile itself—are each equally reliable. Our system then has little value because it is (0.40 x 0.40 x 0.40) per cent, or 6.4 per cent reliable, which is virtually useless. What can we do here?

For one thing, we could make each component more reliable. But is our analysis correct? Will the failure of any one component cause the missile to miss the target? There is ample evidence that it will. No item may fail during its intended tactical life.

How about increasing the reliability of the components from the 99 per cent figures we arbitrarily selected until all components and workmanship are 100 per cent reliable? Excellent for missile system reliability, but an impossible assignment. Why this will never happen is discussed by Marcus A. Acheson's "Electron Tube Life and Reliability." Pertinent extracts follow: ". . . if we remove all potential defectives in a lot, we will have removed the entire lot, whether it be a lot of tubes, a lot of people, or the pyramids of Egypt. Nothing lasts forever, and everything existing is a potential defective—we can only discover a rate at which this probability occurs, and lay our bets accordingly on the living population."

If you still demand 100 per cent, try to get an automobile with a guarantee that it will be 100 per cent reliable for its intended life. The writer, actively assisted by a skilled procurement organization, has experienced difficulty getting some component vendors to guarantee that their product will be 97

per cent reliable. Nevertheless, complex missile systems still must live up to an over-all reliability of at least 95 per cent. Our standard of reliability for each vital component and assembly, therefore, must exceed 99 per cent. The problem is familiar to missile manufacturers everywhere.

Financial policy makers might turn to reliability control as a means of reducing the staggering maintenance costs as well as insuring better field systems. Should the cost of developing and manufacturing a weapon system be doubled or tripled thereby, there would still be a net saving.

Framing the Issue

With statistics you can line up a million-to-one case against the probability of 95 per cent missile reliability. Even so, the missile builder has accepted the challenge.

The engineers at Martin have been conscious of the problem of aircraft reliability through the years, but the yardsticks used for aircraft reliability do not apply directly to missile systems. In fact, missile requiremenets are so exacting and their ramifications so diverse that Martin has established teams of experienced technical personnel to work solely for missile reliability wherever it is at stake. In practice, they move in to monitor every step from drafting board to target, including the design, test, production, and operational phases. Working with mathematics, testing methods, and design techniques, they integrate the requisite reliability control into the original engineering releases. Follow-up studies lead to recommendations for corrective measures in all phases affecting the missile system.

The total reliability cost for a typical Martin missile system amounts to roughly $3-million yearly. This figure includes expenditures for testing components, systems and equipment both in the laboratory and on the firing range. Roughly five percent of the engineering man-hours in this project go directly into the reliability effort. This compares to zero hours and zero dollars a few years ago before reliability became a missile problem.

In order to assure optimum results at minimum cost, it has been necessary to formalize the position of reliability engineering in the company's research, development and production structure. An article detailing how this has been done is planned for a later issue of m/r. ★



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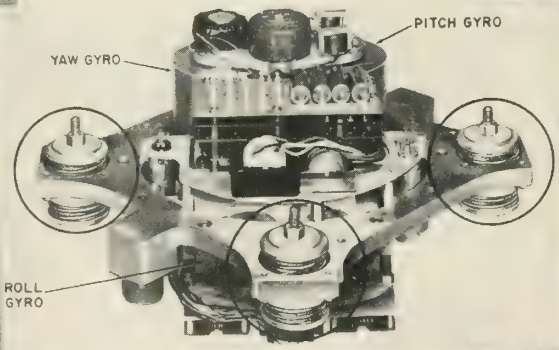
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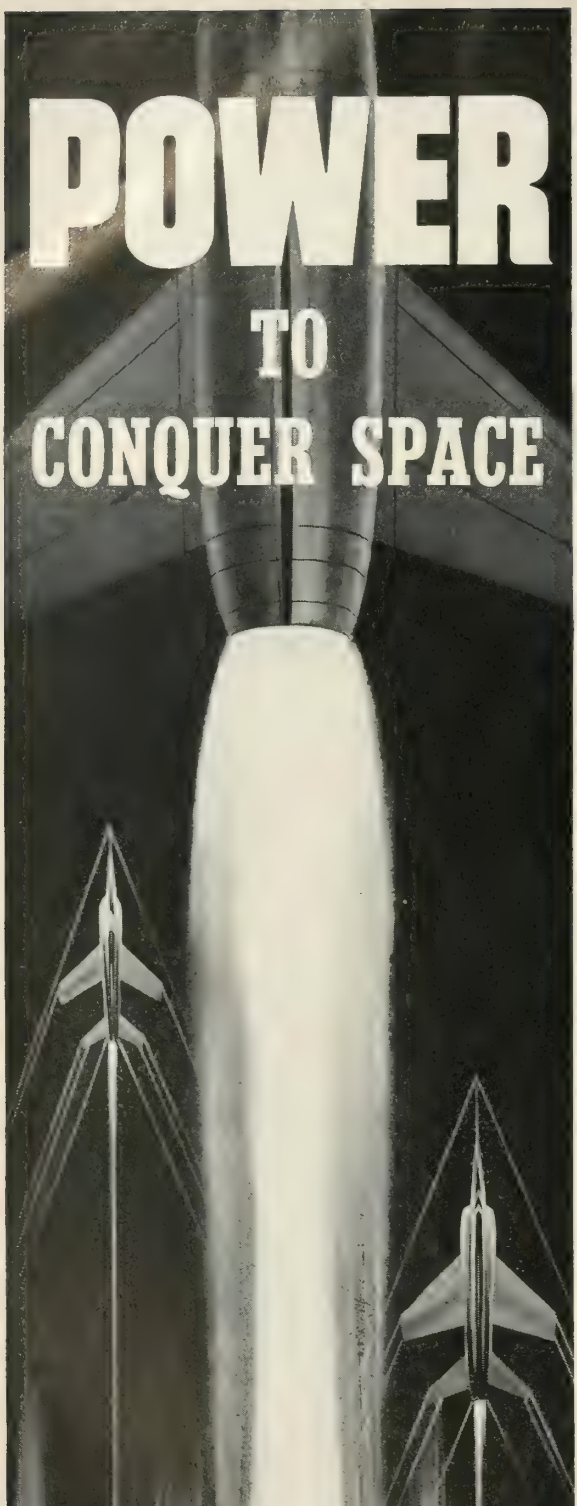
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Cold Facts on a Hot Seat . . .

Rocket Sleds Help Supersonic Bailout Design

By Norman Baker
Boeing Aircraft Company

Thirteen major aircraft companies now are working cooperatively on an ejection seat development program. The objectives of this program will be to develop a standard upward ejection seat that will be compatible to the new supersonic jet fighter-type aircraft. The Industry Crew Escape Systems Committee (ICESC) was set up to coordinate overall program activities.

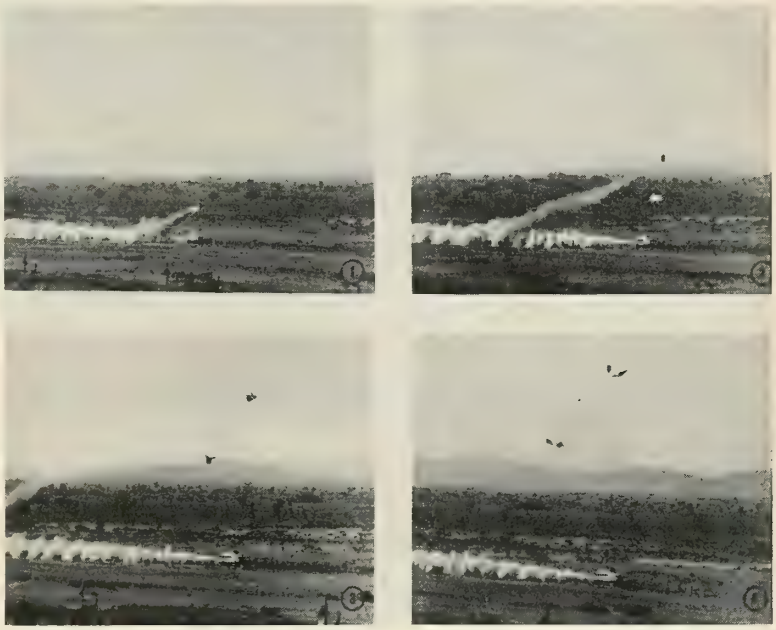
The ARDC has assigned Convair Division of General Dynamics Corp. to coordinate the ejection seat development program. Convair, in this capacity, has subcontracted portions of the development to other companies.

The most recent and outstanding ejection accomplishment of this program has been the development of the RESCU Mark I ejection seat (Rocket Ejection Seat Catapult Upward). RESCU Mark I seat is produced by Talco Engineering Co., Inc., Hamden, Conn. It combines a normal cartridge catapult with rocket propulsion.

RESCU Mark I operates on a two-step principle. The first step in the ejection sequence ignites a ¼ lb charge which propels the pilot's seat vertically. This phase of the operation operates in piston fashion similar to the standard M3 telescoping tube seat catapult. The M3 ejection system propels the pilot upwards, clear of the plane, where he is subjected to the force of the windblast. The tremendous deceleration due to the windblast is the contributing factor for reducing the pilot's chance for survival. The rocket propulsion unit on the RESCU Mark I fires as soon as the seat is clear of the cockpit. A 5-lb. propellant grain fired through a canted nozzle carries the pilot further from the aircraft.

Thrust of the rocket is in a line through the center of gravity of the seat-pilot combination. This adds a forward force vector to the ejection line of travel imparting a resultant forward force which tends to offset the force of the windblast. The thrust through the center of gravity of the seat-pilot unit creates dampening forces which reduce tumbling.

Convair Engineering Test Laboratory engineers and Air Force technicians recently made comparison tests



High-speed sequence camera records ejection of two dummies from Convair TF-102A rocket sled at Edwards AFB in California. 1) RESCU Mark I seat, trailing smoke from rocket clears cockpit. 2) M3 cartridge seat (arrow) is ejected as RESCU Mark I rocket burns out. 3) Rocket seat follows trajectory well above M3 seat. 4) Dummies separate from the seats. Elapsed time: less than one second. 5) Parachutes on dummies start to open. 6) Parachute of RESCU Mark I has opened fully. 7) Rocket propelled dummy starts to assume vertical attitude while M3 propelled dummy is still horizontal. Seat is upper right. 8) RESCU Mark I dummy (upper) making safe normal descent .M3 dummy is still in an unstable attitude.

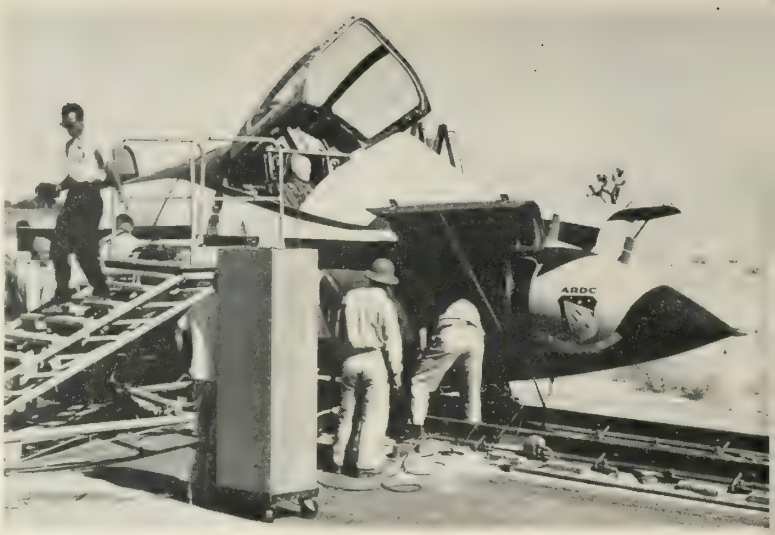
of the M3 and RESCU Mark I ejection systems. Two instrumented anthropomorphic dummies were mounted in seats on a TF-102A nose section rocket sled at Edwards AFB test track. The side-by-side seating of the TF-102A trainer cockpit afforded the engineers an excellent opportunity for comparing the RESCU Mark I and the M3 ejection systems.

One seat was ejected by the RESCU Mark I unit, while the other seat was ejected by the M3-type cartridge catapult. Recent tests at Edwards, first of a long-range development program, were run at Mach .3 and Mach .73. In these initial tests the rocket propelled seat followed a much higher trajectory and the parachute attached to the dummy blossomed more fully than that of the dummy ejected by the M3. This resulted in a more stable, normal descent by the RESCU Mark 1 propelled dummy.

In the first test at Mach .3, the rocket seat propelled its dummy 124 feet above the ground. During this time M3 ejected seat had hoisted its dummy to a height of only 55 feet. During the second test at Mach .73, the rocket seat ejected the dummy to a height of 60 feet above the TF-102A's vertical fin. The seat ejected by the RESCU Mark I system experienced a smooth acceleration, instead of the explosive jolt produced by the M3 cartridge. This reduces the hazard of spinal compression which could be experienced during the ejection by the M3.

The entire sequence of ejection was recorded during these test runs by still, high-speed-sequence and motion picture cameras. Two telemeter transmitters were located on the sled and one in one of the dummies for further correlation of test information.

John G. Kalogeris, Convair engineer in charge of tests at Edwards, states that the new rocket seat "for the first time gives the pilot a good chance of ejecting safely from ground level in case of emergency."



Preparing for takeoff. Air Force and Convair engineers ready TF-102 sled for seat ejection test.

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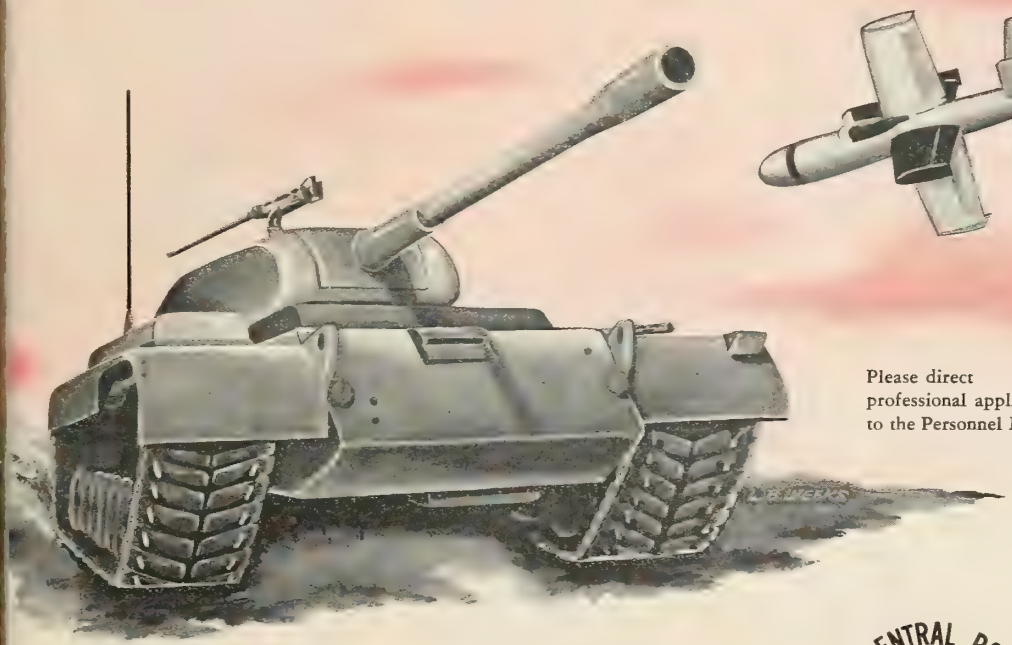
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Tailoring Molecules *for* Rockets

by Dr. David Z. Lippmann



A member of the Chemistry Department Staff at Reaction Motors, Inc., Dr. Lippmann specializes in combustion processes and theoretical analysis. He received his B. S. and M. A. in Chemistry at the University of Texas and his Ph. D. in Physical Chemistry at the University of California at Berkeley. He has been with RMI for three years.

The practical future of rocket power depends upon a great many factors—not the least of which is the solution of the problems facing the rocket propellant chemist. The ultimate rocket chemicals—whether nuclear, solid, liquid (mono- or bi-propellant), hybrid or the new "exotic" chemicals —must lie within the limited parameters of certain rigid requirements. This discussion deals with some of those basic considerations which influence the chemist's search for improved high energy rocket propellants.

The conventional rocket motor is a heat engine which converts the chemical energy of propellants into heat and the heat into kinetic energy. Propellants react in the combustion chamber of the rocket motor, releasing heat and forming gaseous products, which expand through a nozzle; the expansion converts part of their heat energy into kinetic energy. The gases, now moving at high velocity, are exhausted to the rear, and by the reaction principle they impart a forward force, measured in pounds of thrust, to the motor.

The thrust exerted by a rocket motor is proportional to the exhaust velocity of the reaction products. To produce a high exhaust velocity, the reaction of the propellants must yield a large quantity of heat per unit mass and this heat must be converted into kinetic energy efficiently.

The heat produced is the difference between the heat of formation of the propellants and the heat of formation of the reaction products; so the propellants should have large positive heats of formation and give products with large negative heats of formation. Because of the requirement for large heat of reaction per unit mass (not per mole), only the lightest elements are used in propellants. The most desirable elements are hydrogen, lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine, magnesium, aluminum and silicon; elements heavier than chlorine are rarely used. The heats of formation of propellants are maximized by incorporating high energy groups such as $-C\equiv C-$, $>N-N<$ and $-OO-$ into the propellant molecules.

The efficiency of conversion of heat into kinetic energy is inversely proportional to the mean molecular weight of the reaction products. Therefore propellants are designed to give light products, such as H_2, H_2O and CO.

These three requirements, i.e., that the propellants have large positive heats of formation, that the products of reaction have large negative heats of formation, and that the products have low molecular weights, cannot all be optimized simultaneously. A good propellant must have an optimum balance among them. In addition, a propellant should have other desirable properties, such as stability and high density.

The chemistry laboratories at RMI, in support of the applied research, development and production of advanced rocket power systems, are staffed with a team of specialists, highly qualified in many phases of chemistry and chemical engineering. This team is constantly working toward the achievement of this optimum balance of properties in their search for advanced rocket propellants. The well-rounded program of research, analysis and evaluation which contributes to this goal includes such typical activities as mathematical analysis, theoretical chemistry, propellant formulation, combustion chemistry, organic and inorganic synthesis, physical properties and analysis, with special sections devoted to solid and liquid propellant research.

4870

If you desire one or more reprints of Dr. Lippmann's article, or would like to receive additional information about RMI, write to our Information Services Coordinator. Reaction Motors, Inc., 16 Ford Road, Denville, New Jersey.



Rockets for Black Gold



Proving that what goes up must come down, Grand Central Rocket Co. has developed a rocket for ramming new life into old and tired oil wells. Using a specially designed, controlled burning rocket motor sealed in the bottom of the well to build up pressure that exhausts through blowout plugs, oilwell engineers have exerted downward pressures equivalent to 5000 hydraulic horsepower in a single surge. In some cases the resulting soil fractures have enabled pumping rates to be increased 300 per cent. In the drawing, the igniter is at the top; rocket fuel in the middle; and firing nozzle at the bottom. The entire unit is only seven-and-a-half feet long and is dropped readily down the well casing. This is the first commercial use of one of Grand Central's solid rockets. The company also has the third stage Vanguard contract.

Humidity Control for Rocket Propellants

Working under a United States Air Force contract, Phillips Petroleum Company is utilizing related petroleum and chemical technology, their research knowledge and experience to develop new solid rocket fuels. These propellants are prepared and tested in small rocket motors at Bartlesville, Okla.

A chemical-type humidity conditioning system which serves this laboratory plays a vital role in the success of this program. Some of the chemicals used to compound these propellants are extremely hygroscopic. Both the physical and ballistic properties of the propellants are dependent on moisture present during processing. Tests on successive charges from a single batch could vary widely if change in moisture content occurred.

Solid propellant JATO units have been used for several years but have been made of expensive ingredients having limited availability. Phillips researchers are striving to develop a solid, less expensive propellant made of ingredients readily available in this country in large commercial quantities.

Several have been developed and are now being tested. Relatively simple devices, they ignite and burn in bottles or motors which can be made of inexpensive steel. Burning evenly and rapidly, the resulting gases travel through the nozzle at tremendous speeds.

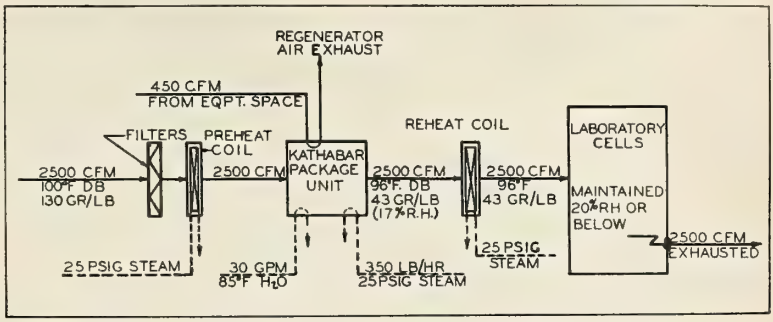
In the ideal JATO rocket there is little flash or smoke and the gases are not toxic or corrosive. Once compounded and sealed in the motor, it should not vary in physical or firing properties even under tropic or arctic storage conditions.

Need for Humidity Control

Much of the solid propellant fuel development is "classified" for security reasons. Actual components cannot be named. It can be said, however, that the principal ingredients are a chemical oxidizer mixed with a binding agent which serves as the fuel.

Some of the chemicals used to form these charges are hygroscopic and are dried before use. To protect their physical properties during compounding and to insure accurate ballistic results from an entire batch, charges must be protected from moisture remain.

Initially a dessicant system was installed to maintain conditions in the laboratory cells at from 25 to 30 per cent relative humidity. In this humidity range the moisture in the air and that in the chemicals were barely at equilibrium. This dehumidifying equipment proved unsuccessful as it could not handle the sudden, high moisture loads placed upon it.



Schematic layout of Phillips Petroleum Co.'s humidity control system.

Many of the test cells are regularly hosed down to cleanse the surfaces of accumulated propellant dust particles. After various other systems were investigated, a very successful chemical-type dehumidification system was installed.

These units, two of which are used in the laboratory, are Kathabar Humidity Conditioners, manufactured by Surface Combustion Corporation, Toledo, Ohio.

Air Conditioning System

In Figure above is shown a schematic flow diagram of one of the Kathabar systems. All fresh air is used to avoid the accumulation of rocket fuel dust in filters and ductwork.

The 2500 cfm of air is shown entering the system at 100°F dry bulb and 130 grains of moisture per pound, maximum summer design conditions. This air passes through filters and enters the unit's air washer chamber. Both the preheat coil and the afterheat coil are for winter operation.

This system uses a liquid absorbent called Kathene. Its moisture absorbing capacity is a function of its concentration and temperature.

Thus, the Kathene solution at a set concentration is cooled in the air washer chamber to the temperature predetermined for proper dehumidification. Automatic regeneration in a separate chamber is accomplished by heating the solution with steam.





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hofman Laboratories, Inc., Newark, N. J.

West Coast Agent: BLAIR-MARTIN CO., INC., 1010 Fair Oaks, So. Pasadena, Calif.

In the air washer chamber the air stream contacts a flood of the Kathene solution as both pass over the extended surface cooling coils. The coolant in these coils both cools the absorbent solution to the right temperature for dehumidification and cools the air. The air is dehumidified and goes on to the distribution duct system. The solution falls into a sump from which it is pumped back to the top of the air washer chamber for additional dehumidification passes. A small quantity of solution is also pumped to spray heads in the regenerator.

When the solution becomes diluted, steam is passed through the coil in the regenerator. This heats the solution, forcing it to give up the absorbed moisture. The solution falls into the sump once more and the released moisture is entrained by a scavenger air stream, 450 cfm as indicated on the drawing, and vented outside. Regeneration is completely automatic.

After the dehumidification pass, the air, at 96°F, 46 gr/lb (17% RH) is ducted to each test cell. The cells are constructed of double reinforced concrete, one foot thick. They are baffled to contain shrapnel in case of an explosion and have blow-out panels to allow the explosion force and gases to escape.

Maximum utility requirements of this system are 30 g.p.m. of 85°F water and 350 lb/hr of 25 psig steam. The unit has a wide range of turndown. When outside conditions are not maximum design, it will deliver air at 17 percent RH and much lower, still using only 85°F water. Less steam is also required when outside conditions are below 100° F and 130 gr/lb. The second unit, 1350 cfm capacity is now placed on standby. Connected to the same duct system it can be utilized if increased activities should overload the first unit, or when planned expansion is authorized in the future. All duct work in the system is interconnected to allow the entire 2500 cfm to be directed to one, two or any combination of test cells if needed.

In the southwest, electric power is more expensive than any other energy source. Since this unit has only a ¾ h.p. pump motor and a 1 h.p regenerator air fan, operating costs compared to other systems are much less. As these are the only moving parts of the system, only routine maintenance is necessary.

Another factor in favor of this system is that there is no "carryover" of absorbent solution in the leaving air stream. Carryover of any kind would impair the accurate compounding and testing of rocket charges. ★

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BOEING

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Servomechanisms, Inc. designed and developed the Redstone's Thrust Controller system, which operates to maintain constant pressure in the Rocket Thrust Chamber. As an indication of its accuracy and reliability, the system controlled pressures to within 1% of the CHAMBER PRESSURE in hundreds of hot firings.

This is an excellent example of how Servomechanisms, Inc. has utilized the experience, acquired through years of developing accurate and reliable sub-systems for high performance jet aircraft, to make a substantial contribution to the guided missile field. Many other developments in this field are now in progress.

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Propulsion Notes

By Alfred J. Zaehringer

California Research Corp. has patented a rocket fuel (acyclic mercaptans with 1-5 carbon atoms) for hypergolic use with nitric acid. Mixed mercaptans obtained from naptha cracking process can be used. The fuel can also be blended with up to 50% volume of hydrocarbon fuels. Small additions (2-to-20%) of nitric oxide, sulfuric acid, or $NOHSO_4$ to the oxidizer reduces ignition delay. A 1:3 (volume) mixture of ethyl mercaptan and nitric acid (with 15% sulfuric) gave an ignition delay of 10 milliseconds at —40° F.

Add to the growing list of "Zip" investigators. Diborane flame studies have been reported by Battelle Memorial Institute and the Royal Aircraft Establishment. In stability studies Battelle ran into unusual flame holding effects and other abnormal behavior, apparently caused by the deposition of large amounts of B_2O_3 slag in flameholders.

The French have devised a continuous method for producing isopropyl nitrate. The direct interaction of nitric acid and isopropyl alcohol gives a 78% yield based on the original amount of alcohol.

Eugen Saenger of the Research Institute for Physics of Jet Propulsion (Stuttgart, Germany) hypothesizes that "photonic gas," a type of radiation, may govern the mechanism of propellant combustion and the detonation of solid and liquid explosives.

British Imperial Chemical Industries has come up with a new solid propellant for low-pressure or rocket propulsion. Oxidizer is guanidine nitrate (88.75%). Polymitrophenols or polynitrosophenols (10-35%) are used to "sensitize" the thermal decomposition of the oxidizer. Catalyst is vanadium pentoxide (0.2-1%). Other additives are asbestos fibers (0.5%) and potassium nitrate (0.25%). Apparently the propellant is formed into grains by compression.

General Electric has in operation a $2 million Propellant Development Lab. at Evendale, Ohio for exploring the combustion of new fuels "with heavier hydrocarbons than JP fuel."

Hydrazine for propellant use is still small. Present cost is $2-3/lb. Present producers are Olin Mathieson and Fairmount Chemical. Stanford Research Institute is now working on a non-aqueous electrochemical process which could bring costs way down.

Next producer of UDMH may be Metalectro (Laurel, Md.) recently acquired by National Distillers Products Corp. Present producers are Commercial Solvents, Food Machinery, and Olin Mathieson.

The Navy has awarded a $38 million contract to Callery Chemical to build a high energy chemical fuel plant. Probable production: pentaborane for chemically fueled bombers.

Ammonium picrate for solid propellants now seems dead. The last government production plant at Little Rock, Ark. is to be sold.

Look to Canadian Industries, Ltd. to enter the solid propellant field. Location may be at its Nobel Works in Ontario, Beloeil Quebec, or Edmonton, Alberta.

Production of hydrogen peroxide is now near 45 million lbs./yr. Latest entries in the production field are Solvay Process at Syracuse, N. Y., Shell Chemical at Norco, La., and Columbia-Southern at Barberton, Ohio. Estimates are that 30-50% of total production goes into military use.

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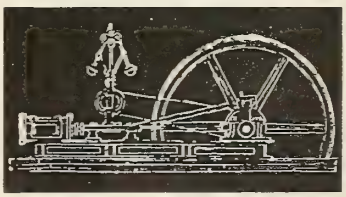
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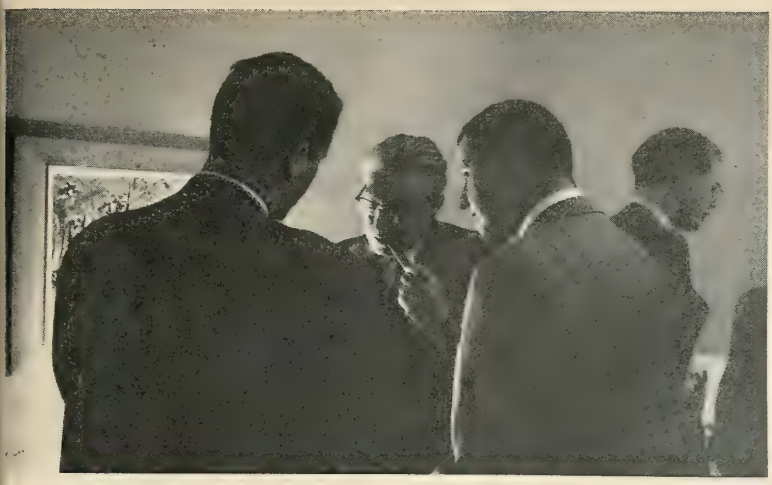
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- Transistor Application Engineers
- Thermodynamic Engineers
- Telemetering Engineers
- Turbine Pump Designers
- Vibration & Flutter Analysts
- Weapons Systems Engineers
- Wave Guide Development Engineers
- Weights Engineers





In Washington for Defense Department's recent missile auxiliary power unit symposium were Paul Ricks (facing away), AiResearch Project Engineer and ex-Peenemunde researchers Rudolph H. Reichel and Fred R. Kunze, both with Bell Aircraft.

T. I. Paganelli has been appointed ngr. of the Special Radar Projects Sec- ion, General Electric's Heavy Military Electronic Equipment Dept., which is re- sponsible for development of new elec- ronic systems for ballistic missiles. **E. P. Heinemann** has been named manager- naterials of General Electric's Light Mili- ary Electronic Equipment Dept.

Harrison A. Storms, Jr., succeeds **C. . Hansen** as chief engineer of the Los ngeles Div. of North American Aviation. Mr. Storms was formerly mgr. of research nd development.

J. Raymond Berry, Jr. has been ap- ointed Washington representative for North American's Missile Development nd Rocketdyne divisions.

Former CAA Administrator **Fred Lee** as joined Olin Mathieson Chemical Corp. s asst. to **W. Foster,** executive v.p. in harge of high energy fuel operations.

Dr. Louis F. Doty, recently supervisor f weapons systems planning in General lectric's Nuclear Propulsion Dept., rejoins ircraft Armaments, Inc. as head of the erodynamics Dept.

J. F. Forster, vice president and asst. eneral mgr., Vicker's, Inc., has been ap- ointed executive v.p. in charge of all ickers operations.

Andrew F. Haiduck has been named xecutive v.p. of Lear, Inc., supervising nd coordinating activities of all company ivisions and subsidiaries, as well as as- uming duties of **A. G. Handschumacher,** ice president and director of sales, who as joined another company.

Norman F. Trost, formerly with Gen- ral Motors' Aeroproducts Div., has been ppointed president of Narmco Mfg. Co.

Jesse Zabriskie, division mgr. of Bell ircraft's Guided Missiles Div., announced he appointment of **Tex S. Lines** as his ssistant and **John C. Parkin** as director f engineering.

B. F. Coggan was elected vice presi- ent and manager of Convair-San Diego nd **Charles F. Horne,** vice president and anager of Convair-Pomona.

Robert H. Noorduyn has been ap- ointed Dallas district mgr. for Walter idde & Co.'s Aviation Div.

Walter T. Runiewicz and **William M. unwody** have been named chief com- onents engineer and chief systems en- ineer, respectively, for Clifton Precision roducts Co.

Harold C. Erskine, general mgr. of the castings division, has been named asst. general production mgr. for Aluminum Company of America. He was formerly director of the Aluminum and Magnesium Div. of Business and Defense Services Administration, Dept. of Commerce.



PAGANELLI



Senior AiResearch project engineer C. F. Drexell shows press FALCON power unit.



TROST

Richard A. Maher has been appointed chief engineer of Hoffman Laboratories; **Carlton Wasmansdorff,** vice president, has been assigned to the research and development of new electronic systems and products; **E. Philo Davis** has been named manager of advertising and sales promotion; and **Tom C. Clark** has been appointed director of military sales.

Eugene J. Venaglia will be manager of Sperry Rand Corp's new electronics laboratory at Clearwater, Fla.; **Paul T. Cullen** has been promoted from surface armament sales representative to asst. to the president and general mgr. of Sperry Gyroscope Co. **Charles S. Rockwell** has been named vice president and general mgr. of the Ford Instrument Co. div. of Sperry Rand Corp.

C. E. Pappas was named asst. director of scientific research for Republic Aviation Corp.; **Travers Auburn** has joined the company as chief industrial engineer.

Roland C. Webster and **Rudolf H. Edelston** have joined the Chemistry Div. of Atlantic Research Corp., Alexandria, Va., where Webster will work on the development of rocket-powered seat ejectors and Edelston with the design of rocket components and rocket testing equipment.

Franklyn E. Dailey, Jr., has been appointed mgr. of the applied science section, Research and Advanced Development Dept. of Stromberg-Carlson.

Harry E. Pinkerton has been named president of the International Electronics Corp. (Intec), a joint American-French venture into the field of electronics.

Cliff Anliker was appointed supt. of manufacturing of Robertshaw-Fulton Controls Co.'s Aeronautical Div.

Louis E. Benitez has been promoted to director of customer relations for armaments systems, **Thomas J. Mitchel,** to director of electronic systems, and **Perry Smith** to director of commercial sales, Crosley Div., AVCO Manufacturing Corp.

W. R. Miller has been appointed vice president of Longren Aircraft Corp., in charge of Longren de Mexico.

John S. McCarthy was selected as McDonnell Aircraft Corp.'s Dayton, O. representative to handle military relations and engineering.

R. B. Young has been appointed general mgr. of Aerojet-General Corp.'s liquid rocket plant at Sacramento; **Dr. John V. Atanasoff** has been named resident mgr. of Aerojet's Ordnance Engineering Div. at Frederick, Md.



COLE

L. E. Dalton was elected vice president in charge of manufacturing for all divisions of the Kelsey-Hayes Co.

Herman J. Pelkey has been named plant mgr. of the Kellett Aircraft Corp.

Robert A. Cole, supervisor of computation and data processing for Boeing Airplane Co.'s Bomarc project since its inception, has joined Tally Register Corp. as chief engineer.

Dr. James E. Shepherd will direct Sperry Gyroscope's Electronic Tube Div. to be located at Lake Success, N.Y.

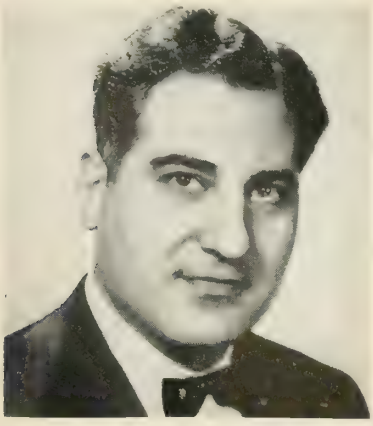
A. A. Demetriou is in charge of new office at Huntsville, Ala., to represent Northrop Aircraft and subsidiary, Radioplane Co., at Redstone Arsenal.

Andrew A. Nargizian, a pioneer member of the World War II Manhattan Project, has been appointed assistant to the president of Avion division of ACF Industries to coordinate missiles systems activities at the Avion plants in Paramus, N. J., Alexandria, Va., and Los Angeles.

Carl W. Bollum, Sr., former deputy chief of the Army Ballistic Missile Agency's Washington Office, was named engineering asst. to the general mgr. of Fairchild Guided Missiles Div.

Douglas B. Nickerson has been appointed chief engineer of Hydro-Aire, Inc., replacing **Richard M. Degen,** resigned. **Lt. Gen L. C. Craigie** (USAF, ret.) has resigned as vice president-engineering of Hydro-Aire but will continue to serve as a director and consultant.

Richard L. Bean has been appointed public relations mgr. of Lockheed Aircraft Corp.'s California Div., succeeding **William R. Wilson** who has been assigned as director of market development in Lockheed's expanded aircraft sales organization.



NARGIZIAN

Raymond J. Condon has been appointed vice president in charge of government projects for Minneapolis-Honeywell, with headquarters in Washington, D.C.

Stanley W. Burriss and **John H. Carter** have been named managers of the weapon system organization, Lockheed's Missile Systems Div., at Sunnyvale and Palo Alto, Calif. respectively.

Richard B. Gulliver has been appointed mgr. of industrial relations of the Fairchild Guided Missiles Div., replacing **Lynn G. Walck,** resigned. **John W. Robinson** has been named public relations asst. for Fairchild Engine and Airplane Corp.

Dave N. Peterson, formerly executive advisor to vice pres. **Stan Smithson,** has been named facilities administrator for North American Aviation's Missile Development division. **Norman P. Hays,** retired Air Force colonel and formerly chief of the Armament Laboratory's Strategic Bombing Branch, was appointed asst. to the gen. mgr. of the Autonetics division. **Robert J. Clark** has been named mgr. of North American's new European office in Geneva, Switzerland.



BOLLUM

C. A. Gongwer, co-inventor of the MiniSub, has been appointed to the new Large Solid Propellant Rocket Advisory Committee of the Aerojet-General Corp.

Donald E. Brown has been appointed chief engineer of Consolidated Electrodynamics Corp.'s Glendale div.

Under a new setup at Northrop Aircraft, Inc., **Robert R. Miller,** vice president and gen. mgr. of the present company, becomes corporation vice pres. and gen. mgr. of the Northrop Div., embracing the company's aircraft and missile facilities; **Dr. William F. Ballhaus,** chief engineer of Northrop, was elected vice pres. and chief engineer of the Northrop Div.

Charles E. Arnold has been appointed mgr. of the Avionics Laboratory of Sylvania Electric Products Inc. and **Frederick J. Anderson** is assistant mgr.

Frank M. Viles, Jr., has been named vice pres. in charge of manufacture of semi-conductors of Federal Telephone and Radio Co., a div. of International Tel. and Tel. Corp.

George H. McKaig is the new mgr. of production planning and **James T. Jones** has been named mgr. of production engineering at Hughes Aircraft Co.'s manufacturing div.



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A Vought Vignette

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The Aircraft Designer Who Went to Sea . . .

IT WAS A ROUTINE CRUISE for the *Bon Homme Richard*. But for Wayne Burch, it was a memorable climax to months of hard work. Aboard the carrier with the Chance Vought design specialist was the white-lacquered fighter he'd worked on so long.

★

Wayne had joined the Crusader dayfighter project in Preliminary Design, on alighting and arresting gear. He'd transposed his initial drawings into detail design and, later, he'd watched his gear pass jig and aircraft drop tests. At the Navy Test Center, the Crusader's gear absorbed maximum sink speeds and arresting tension, and Burch once more was there.

★

Now, Navy pilots on the *Bon Homme Richard* were taking the Crusader to sea, and Burch was going along. This time his assignment was simply to watch, and this time the Crusader was to be just part of the picture. Vought wanted him to experience carrier life and to see how his new weapon fitted in. For Wayne, whose sea log began and ended with one day's fishing from a 20-foot launch, it promised to be an eye-opening voyage.

For six days the designer shared quarters with Navy fighter pilots and had coffee with maintenance men. He studied aircraft spotting and catapulting, and he learned the sign language of the LSO (Landing Signal Officer). He marveled at the fingersnap timing of the Navy's deck handlers and at the *Bon Homme Richard's* mid-voyage refueling of two bobbing destroyers.

★

Wayne calls it "one of the most enjoyable weeks of my life" . . . and, as other sea-going Vought engineers have discovered, "one of the most profitable, too.

"Now I know the pilot's job, what maintenance wants . . . how really big the operation is.

"It's something you don't get if you stick too close to design.

"I guess you'd call it *perspective*."

At Chance Vought the designer stays in touch with his product . . . Contact begins in development, extends through test and includes, when possible, a study by the designer of the tactical environment in which his weapon will serve.

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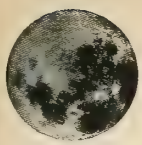
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Missile Miscellany

An old and thinking friend who actually doesn't wish to quarrel with Einstein has a question about a clock at speed that goes slower: "According to Relativity, the clock in motion can be considered at rest, and the clock at rest, in turn, can be considered to be in motion. Doesn't this raise the possibility that when the journey's finally over and the two clocks are back together, each will be slower than the other?"

Relativity also requires the equivalence of gravitic and inertial mass. If so, explain why a gravity pendulum with a bismuth bob gains one beat in 17.432 by another pendulum of exactly the same oscillation length having a zinc bob; and why torsion pendulums act similarly.

And out of Chicago, an industrial designer with some engineering knowhow feels the "blasting off" rocket is about as primitive as a Chinese firecracker, and as close to what a space ship will look like as the ornithopter was to the airplane.

A rocket engineer cloud-walking the recent space-flight symposium figures berrylium liquid propellants may result in a 0.96 mass ratio and a practical two-step moon vehicle . . .and from elsewhere, recent reports of exotic additives to solid propellents. This page also hears of concern over the possibility of radiation damage to rocket fuels at high altitudes . . . And then, there's the AF major who wants to transport ice and water from Jupiter to Venus so as to make the latter inhabitable.

Navy, researching a way to make domesticated algae do a quicker conversion job of CO_2-to-O_2, is bothered by algae who shade their brothers from light source—wonders how to "mix light in" with little fellows. Is this for permanently submerged atomic submarines, or space ships?

This page too has its "authoritative sources", one of whom tells that in exchange for missile knowhow and hardware, Britain will supply U.S. with IRBM bases.

Overheard from a disgruntled radar operator dangling his toes in the blue Pacific: "A Regulus launched from a submarine made it unscathed to target through combined coastal defenses". . . . This page also learned that some one finally thought of podded tanks for extending range of the air-breathers now in service . . . a sound system expert with a 25-year interest in rocket mail reports that Italy last year issued a stamp with a satellite circling the world . . . of Wernher von Braun's products, this comment from a major missile component supplier: "—cast iron products that look like flying washing machines, but practical" . . . a reference to the Pentagon as the puzzle palace from a Navy combat count-downer . . . while lunching, an aerodynamicist after a frustrating morning trying to rationalize Reynolds numbers, laminar flows and transfer heating rates concluded: "What we're trying to do is sphere the cylinder". . . . with all the talk of hyperthermantic flight, an industry PR who knew no better asked why we don't take aerodynamic heat into the vehicle and put it to work . . . then we met a grinning structures man who's discovered that epoxy-resin bonded fibre-glass now does many hot missile jobs with ease . . . not long ago a Redstone with delusions of Jupiter went 500 miles . . . an Army missile general figures if he waits Wilson will— . . . and in memoriam, acknowledgement to Chinaman Wan-Hoo: about 1200 A.D. he rigged 47 war rockets in fatal attempt at powered flight . . .





INDUSTRY SPOTLIGHT

By Joseph S. Murphy

Plastics Mold Missile Age

A carrying case at 150 feet from ground zero survives an atomic blast virtually undamaged . . . A guided missile nose cone stands the heat and friction generated at three times the speed of sound . . . A vibrating conveyer's springs take 10 million cycles without failure.

These are some of the wonders of reinforced plastics, the 12-year old industrial youngster which is helping smooth the way for the missile age.

Over 1,200 business and industry representatives from a dozen countries looked over the latest offerings of the reinforced plastics industry at its 12th annual Exhibit and Conference in Chicago early in February. The displays showed clearly why almost 140 million pounds of reinforced plastics were consumed in 1956—almost a third more than 1955. A similar rise is expected in 1957.

The versatility of the material, a combination of plastic resin and reinforcing material, seems limitless: from fishing rods to electronic equipment to railroad boxcars. It goes into pleasure boats, patio roofs, sports car bodies, air conditioner housings and tooling.

The aircraft industry ate up 20 per cent of the industry's output in 1956, followed by the construction industry with 16 per cent. The remainder was divided up as follows: boats 16 per cent; consumer products such as luggage, sleds, etc., 10 per cent; automotive, 8 per cent; containers, trays, tanks, 5 per cent; appliances such as laundry tubs, refrigerator liners, water softener housings, etc., 5 per cent; miscellaneous, 20 per cent.

Although polyesters still make up the bulk of the resin used in reinforced plastics, others are moving in: epoxy resin, low pressure phenolic, polystyrene, silicones, melamine, vinyl. Of the 140 million pounds of reinforced plastics sold in 1956 resins accounted for half with reinforcements and fillers making up the remaining half. Breakdown of the resins: 65 million pounds polyesters, 4 million—epoxies, half a million—phenolic and the remaining half million divided among silicones, polystyrene, melamine and vinyl.

The production of polyester resin has jumped from 3½ million pounds in 1945 to 71 million in 1956.

This year's exhibit made a big play for the consumer, displaying a large number of new products currently in mass production:

Streamlined super-market checkout counters (one is being molded every 2½ minutes with more than 7,000 already produced); lightweight translucent silo covers (the potential is thought to be in six figures); outboard cruisers (40,000 reinforced plastic boats in 1956); record players, adding machines, parcel post scales, hammer handles that would take 3,000 pounds to separate from their heads; a sports car with plastic components.

The conference stressed the growing importance of the industry in the electronic equipment field. Increasingly small parts molded of reinforced plastics premix and molding compounds are finding their way into automotive and electronic equipment. More and more, the missile industry is also turning to plastics of different types to fill its exacting and various needs.

A 74-frame color slide film and script, "Designing with Reinforced Plastics," is available for $15 from the Public Relations Department, Society of the Plastics Industry, Inc., 250 Park Ave., New York 17, N. Y. The film probes the uses of reinforced plastics in a wide variety of industries.

Kemsco to Specialize In Cryogenics Field

Kemsco, Inc. of Santa Barbara, Calif. his discontinued manufacture of maritime supplies and will devote future operations exclusively to the field of cryogenics (low temperature), according to its new president James K. La Fleur.

First major missile item it will build is a high-pressure stainless steel reciprocating pump of special design to handle liquid oxygen and nitrogen. It is intended for use at test centers and operating bases in pressurizing missile fuel chambers.

The Kemsco low temperature pump, first of which was due to enter service last month, is designed for a maximum pressure of 10,000 psi and normal operating pressure of 5,500 psi at a flow of 5 gallons per minute.

According to La Fleur, the company has equipped itself for engineering, development, modification and testing of all equipment to be used for low-temperature service. La Fleur was formerly associated with The Garrett Corp. and was chief engineer of Wall Cryogenics before joining Kemsco.

Rototest Opens Facility For 'White Noise' Testing

First independent commercial "white noise" test facility, capable of simulating the noise spectrum of jet and rocket engines up to 150 db, has been opened by Rototest Laboratories, Inc. at Lynwood, Calif.

White noise, an acoustics term that refers to all-frequency testing, is distinguished from discreet noise which refers to a given frequency.

The new Rototest facility is designed to test aircraft and missile components and equipment to the 150 db sound level intensity and produce it over a cross sectional area of 64 sq. in.

According to Rototest, at least three missile producers—Convair, Boeing and Bell—already have included "white noise" test requirements in their specifications for certain components. Company officials also said this type testing is expected to become a standard requirement of the military services in the near future.

New Supersonic LAB Under Construction

New supersonic combustion laboratory being built by Fairchild Engine Division, Fairchild Engine and Airplane Corp., is expected to be completed by mid-May. It will be used for experimental work in aerodynamics and thermodynamics.

Avco Builds R&D Center

Avco Manufacturing Corp. last month broke ground for Wilmington, Mass. for the $15 million R&D center of its Research and Advanced Development Division. Company expects new facility to be in full operation by mid-1958.

Circle No. 14 on Subscriber Service Card.——→

Here's another

New DC Motor by EEMCO



Type D-932, designed and produced as an alternator drive for a 400 cycle supply on a new missile.

EEMCO Type D-932 DC motor operates continuously at a regulated speed of 12,000 rpm, plus or minus ½ of 1%, under the following varying conditions:

From .5 HP to 2.6 HP with a terminal voltage of 27.5 DC, plus or minus 1.5 volts.

The constant speed of 12,000 rpm is maintained by a frequency regulator that supplies the control field of the double-field stator of the motor. Type D-932 has an internal spline, and can be supplied with or without a radio noise filter, which is shown in the illustration.

Type D-932 is another in the series of new AC and DC motors being custom designed and produced currently by **EEMCO** for the latest missiles and supersonic jet aircraft. In fact, there is an **EEMCO** motor or actuator system on the majority of such new weapons now in production or projected for use by our Armed Forces.

This, we believe, is an expression of confidence in **EEMCO**, which for the past 15 years has specialized exclusively in the design and production of motors and actuators, both linear and rotary, for prime and subcontractors in the aircraft industry.

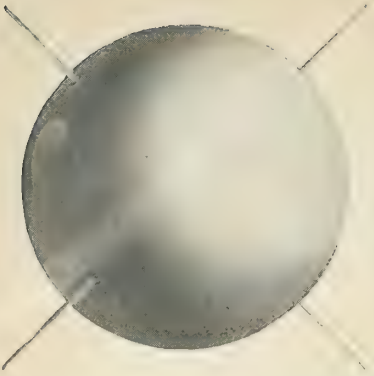
SPECIFICATIONS FOR TYPE D-932

Type: DC motor for alternator drive for 400 cycle supply on a missile.
Speed: Continuous at 12,000 rpm, plus or minus ½ of 1%.
Speed Control: By frequency regulator supplying control field.
Load: From .5 HP minimum to 2.6 HP maximum.
Terminal Voltage: 27.5 DC plus or minus 1½ volts.
Weight: With radio noise filter—13.9 lbs. Without same—12.4 lbs.

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AIR ASSOCIATES INC.,

(SUBSIDIARY:
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Teterboro, N. J.

Industry Highlights



By Fred S. Hunter

Some 80 past and present associates of Dr. W. B. Klemperer, chief scientist for the missiles engineering department at Douglas, organized a surprise dinner to observe his 20th anniversary with the company in a fitting and proper manner. Klemp is an old Zeppelin man who has been through a lot since then and the party brought out considerable reminiscing. Such as how before World War II the Douglas company began to give consideration to the intercept problem and put Klemp to work on it. He came up with a big fat report that Douglas thought a highly intelligent piece of work. It was so good Douglas decided Wright Field should be given the opportunity to see it. Wright Field liked it too. So much so it promptly slapped a great big secret stamp on it. Yep, they had secrets in those days, too. After that no one at Douglas was allowed access to the report, including Klemp himself.

The Klemperer dinner reminded Bernard Benson, president of Benson-Lehner Corp., of the early days of missile firing. First, they chased the cows off the range. Then they touched a few wires together and counted one, two, three—GO! "That was before we learned to count backward," grinned Benson.

•

Magnitude of an ICBM test program is illustrated by the fact that Convair has had personnel assigned to the Air Force Missile Test Center at Patrick AFB since 1953, where one of these days, now four years later, the *Atlas* will be launched over the range extending out into the Atlantic. By the time Convair is up to full-scale test operations on the *Atlas* it will have a payroll of 450 people at Patrick. Convair also has had test personnel at the Edwards Rocket Base in California since 1955, two years, working on the test program for the *Atlas* power plants.

North American's engine test site at Santa Susanna represents another example of what rocket testing entails. Rocketdyne has 19 test stands at Santa Susanna and averages one test per stand per shift (2) per day. It uses 250,000 feet of oscillograph paper a month and 300,000 feet of magnetic tape recording the data.

Little things add up: Lockheed Missile Systems division saved 1000 man-hours on a mockup job by switching from plaster to stryofoam, a lightweight plastic that can be cut to any shape and then solidified by an overcoat of plastic-painted glass cloth. A safety committeeman at MSD observed that constant hammering broke down the surfaces of blunt-edged chisels, leaving sharp rough ends that chipped off into flying bits of steel that imbed themselves into workers' fingers, hands and arms. He suggested that chisel tops be kept round and polished. An inspection turned up only one that did not need repolishing.

•

Engineering data unit at Atomics International has replaced the standard file cabinets formerly used by engineering drawings with an open library-type steel shelf rack. Boyd Corwin, unit supervisor, estimates the 12 x 7 ft. open rack takes the place of 20 file cabinets, a saving of 50% in floor space and a substantial amount in equipment cost. Filing is easier, so handling time is reduced.

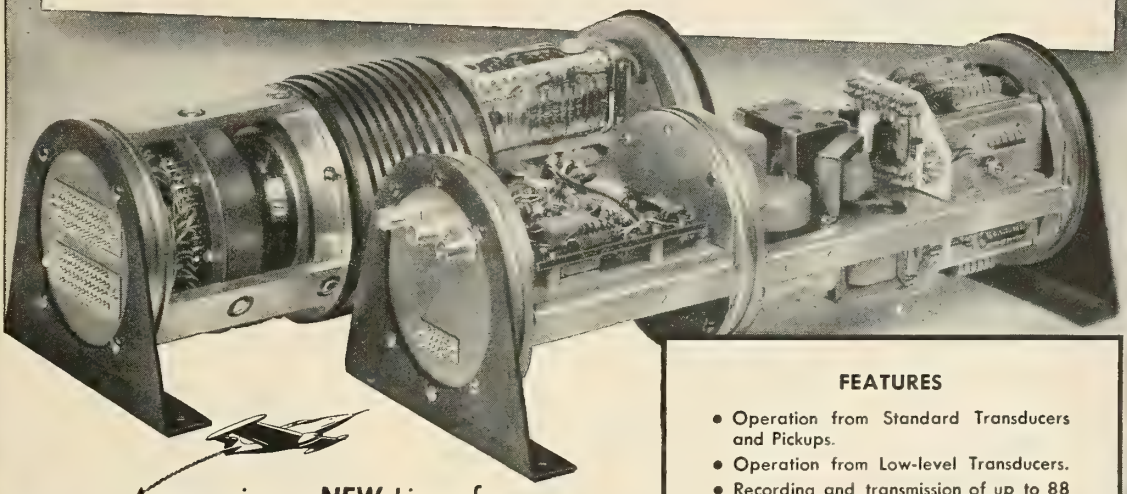
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Tripling of Northrop Aircraft's Torrance facility is related to growing projects on the intercontinental Snark . . . Marquardt Aircraft netted a substantially increased profit in 1956, but Roy Marquardt says the earnings will be reinvested in the business to pay for future growth.

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For Remote Measurement, Recording, Transmission

The new ASCOP D Series PW Multicoders provide, for the first time, supersensitive, low-level remote measurement of data from airborne vehicles. The extremely high input sensitivity, fast sampling rate, and wide selection of data channels (up to 88) of these new Multicoders . . . together with their critical accuracy, ultra-high altitude pressurization, and rugged design . . . suit them ideally to today's most important testing and prototype applications involving recovery and repeat use.

Provides A Complete Data System

The new ASCOP Multicoder, combined with ASCOP M Series Ground Station Equipment and suitable transmission or recording equipment, constitutes a complete data handling system that is easy to operate, flexible in application and provides simplified real time reduction. ASCOP also produces a complete line of PW Data Systems and equipment, Telemetering sets and High and Low Speed Rotary Sampling Switches. Contact ASCOP regarding your present program *today*.

FEATURES

- Operation from Standard Transducers and Pickups.
- Operation from Low-level Transducers.
- Recording and transmission of up to 88 data channels.
- Ease of data reduction.
- Pressurized for very high altitudes

SPECIFICATIONS

- **Input Sensitivity:** 0-15 mv or 0-30 mv
- **Input Circuit:** Differential balanced to ground
- **Data Channels:** 43 or 88
- **Sampling Rate:** 20 or 10 samples per second per channel
- **Output:** Standard pulse width
- **Power Requirements:** 115V, 400 cycles

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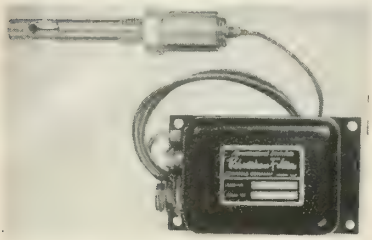
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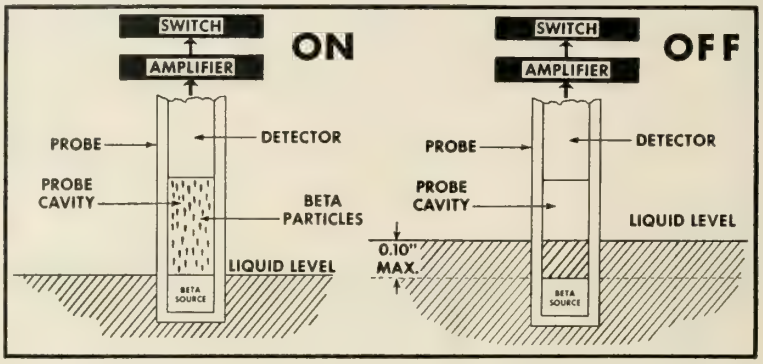
ASCOP

WE PROVIDE THE LEVER . . . YOU MOVE THE WORLD

NEW MISSILE PRODUCTS

Robertshaw-Fulton Unveils Liquid Level Switch





A 9-ounce liquid level switch which utilizes radioactive means to sense and control fuel levels in supersonic aircraft and missiles has been unveiled by Robertshaw-Fulton Controls Co. The system consists of a 2-oz. ½ x 4¼ in. probe and a 7-oz. 3¾ x 2 5/16 x 1¼ in. transistorized amplifier of rugged construction to meet aircraft and missile needs.

The sensing probe contains a hermetically-sealed beta source and a beta detector (geiger mueller tube) mounted inside the fuel tank or cell. These are separated by a small cavity into which the liquid flows.

When no liquid is present, radioactive particles pass from the source to the detector; when liquid enters the cavity, the radioactive particles are absorbed and the radiation level is reduced.

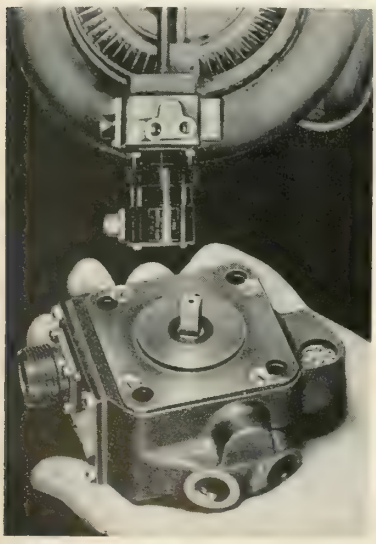
The R-S system converts this change in radiation to an electrical signal, amplifies it by a transistorized circuit, then actuates a relay that is used to energize warning lamps, valves or servo motors to correct the fuel distribution on the aircraft or missile.

Company officials place the signal response time at about 1/20th of a second and its accuracy at —1/10 in. whether liquid level is rising or falling. Switch works on 28 volts d-c at 0.05 amps.

Circle No. 225 on Subscriber Service Card.

SPEED GOVERNOR

A new speed governor and tachometer switch proposed for a variety of



applications in aircraft, drones and missiles has been introduced by The Lee Co.

Essentially a "droop" type governor with a 7% permanent droop, the Lee development has been designed for direct throttling of a propellant to a gas generator and has been used for throttling of JP-4 fuels on small jet engines.

Company officials, however, visualize its potential as a speed regulator on auxiliary power units, overspeed protection device for turbo pump sets, and for sequencing and control of remotely operated engines as on drones or air-launched missiles.

The governor weighs about 1 lb. and measures 3.18" x 4.31" x 1.71" overall.

Circle No. 204 on Subscriber Service Card

ROCKET TEST STAND

Aerophysics Development Corp. subsidiary of Curtiss-Wright Corp. has developed a vertical balancing machine capable of dynamic balancing of rocket motors, rotating launchers, and turbo machines weighing up to 5,000 lbs. in weight.

It is said to handle rocket motors with thrust ratings up to 20,000 lbs. and diameters up to 36 in. Turbo machines or components, such as flywheels, can be accommodated at dimensions up to 10 ft. in length and speeds of 10,000 rpm.

According to ADC, rotating units weighing several hundred pounds have been balanced to an accuracy of about 1,000,000th of a radian. Experience showed that test and correction cycle could be completed in about one hour.

The new balancer will also measure dynamic unbalance of a spinning rocket motor when shut down or firing. In addition, with slight changes in suspension system, it can be adapted for measuring jet misalignment of rocket motors ranging in capacity from 100 to 20,000 lbs. thrust.

Circle No. 206 on Subscriber Service Card

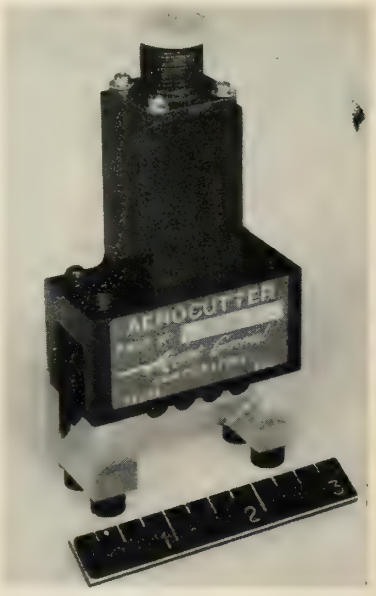
LOW-NOISE BLOWER

Turbo Research Corp. has developed the Model 101 centrifugal blower intended to fill the gap in pressure range between previous centrifugal and axial types used in aircraft and missiles.

The Model 101, featuring a drastic reduction in noise levels, is rated to deliver 1300 cu. ft. of air per minute at 8,000 rpm against a discharge head of 4 psig. Literature available.

Circle No. 208 on Subscriber Service Card

CARTRIDGE-ACTUATED CUTTER



Aerojet-General Corp. has introduced a new cartridge-actuated cutting device that weighs only one pound and occupies 7.5 cu. in. of space for airborne use in severing aircraft and missile system lines.

The Model AGX-1800 Aerocutter, as a typical example, is designed to sever four stainless steel tubes of ¼ in. diameter and .035 in. wall thickness while they are pressurized to 150 psi with corrosive fumes.

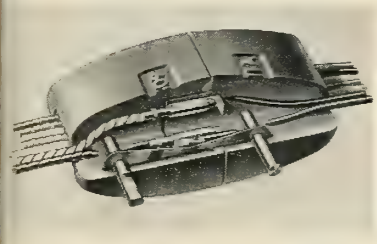
As an added feature, the unit will

cut the tubes so that one end may vent to ambient pressure and swage the other against an anvil to seal it and prevent further flow. It is fired by an electrical impulse which actuates a non-corrosive propellant and may be reloaded for repeated use.

In addition to airborne applications, the company proposed use of the Aerocutter in safety systems for nuclear reactors, as well as for hydraulic or pneumatic devices and mobile ground equipment.

Circle No. 207 on Subscriber Service Card

MISSILE CONNECTORS



New series of electrical connectors which feature the molding of insulation directly onto contacts and leads has been introduced by Alden Products Co.

The new design, intended for use in fool-proof, tamper-proof cables for critical aircraft and missile operations, calls for molding of contacts and leads with one hot shot of connector insulation into connector bodies arranged integrally within their cables.

Among special IMI (integral molded insulation) connectors unveiled by Alden is an umbilical disconnect for missile use.

Circle No. 214 on Subscriber Service Card

PROPELLANT PUMP

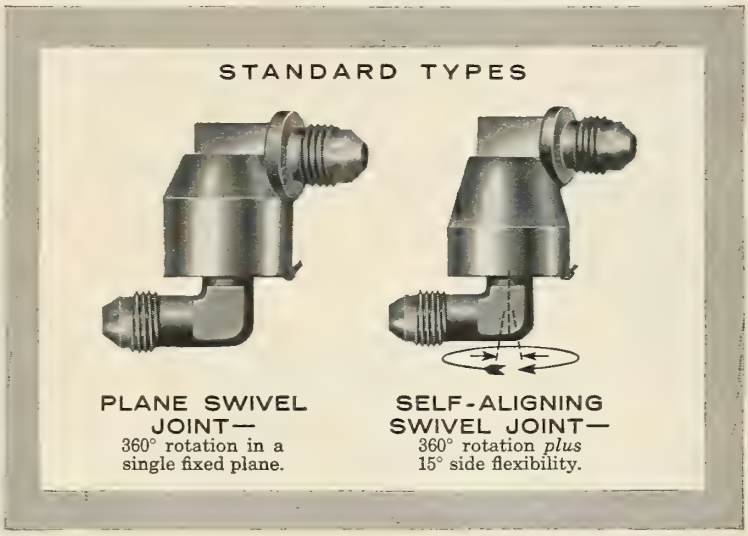


A new ball-piston type missile fuel pump designed for handling low viscosity, low-lubricity, highly corrosive propellants such as normal propyl nitrate has been announced by General Electric Co.'s Aircraft Products Dept.

At 260°F, the GE pump is rated to deliver 0.50 gallons of propyl nitrate per minute. In addition, GE states, use of corrosion resistant materials in its construction makes the pump suitable for high-temperature operation with many other exotic missile fuels.

Circle No. 205 on Subscriber Service Card

these 2 basic BARCO joints bring flexibility unlimited to piping and tubing

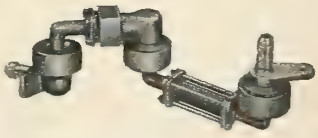


for MISSILES and ROCKETS —Launching and Fueling Assemblies

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This wide experience is yours to call upon in the development of your particular project—rocket, missile, or special installation—for hydraulic, pneumatic, oxygen, fuel, gas or liquid service. Barco Representatives are at your service in the specification of standard or specialized adaptations of standard designs.

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MISSILE LAUNCHER HYDRAULIC ASSEMBLY



WING FOLD HYDRAULIC ASSEMBLY

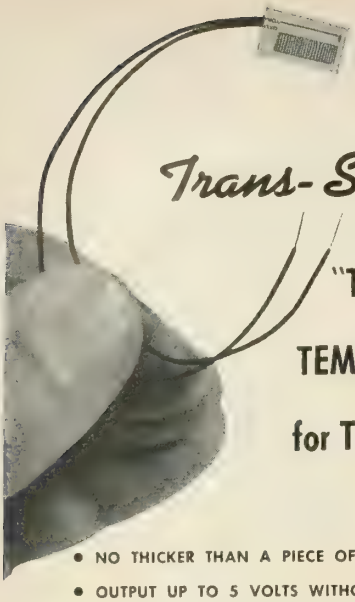


SEND FOR NEW CATALOG 269-A
—gives details on Barco swivel joints and other application to many types of flexible assemblies.

Barco also offers other special flexible joints for handling nitric acid and liquid oxygen. For temperatures from −300°F. to 1000°F. Sizes to 6″. Send for data and literature—specify service.

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NEW

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"TAPE-ON" SURFACE TEMPERATURE RESISTORS

for Temperature Telemetering

- NO THICKER THAN A PIECE OF TAPE
- OUTPUT UP TO 5 VOLTS WITHOUT AMPLIFICATION
- AVAILABLE IN VARIOUS RANGES FROM −300° to +400°F.
- RESISTANCE CHANGE OF 100 OHMS OVER SPECIFIED RANGE
- NO HOLES TO DRILL — QUICK AND EASY "TAPE-ON" INSTALLATION

Trans-Sonics Type 1371 "Tape-on" Surface Temperature Resistors are precision resistance thermometers with a platinum resistance winding as the sensing element. These resistors which are no thicker than a piece of tape may be applied to *any surface* whose temperatures are to be measured. In a commutation circuit, they modulate standard telemetering transmitters without amplification. The new Type 1371 "Tape-on" Surface Temperature Resistors may be added to an installation using other Trans-Sonics temperature transducers without any further circuit modification. Each resistor is furnished with 6" long fibreglas-covered constantan leads. Write for Bulletin 1371 to Trans-Sonics, Inc., Dept. 9.

*Reg. Trademark

SPECIFICATIONS

SIZE: ¼" x 5/16"

Accuracy: ±2% of full scale range

Precision: ±0.5% of full scale range

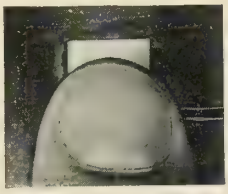
Maximum Continuous Current: 20 ma rms (averaged over 1 second)

Environmental Operation Conditions

Vibration: 1" double amplitude, 0 to 22 cps ± 25g, 22 to 2000 cps

Shock: 100g in any direction, per paragraph 4.15.1 of MIL-E-5272A (10 milliseconds shock)

INSTANT INSTALLATION



As easy to apply as a thumb print.

For Transducers, See Trans-Sonics

Trans-Sonics, Inc.

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Circle No. 43 on Subscriber Service Card.

MISSILE RECORDER

A miniature magnetic tape recorder, already used to secure skin temperature data in high-speed, high-altitude flights of Aerophysics Development Corp.'s HTV (hypersonic test vehicle) has been introduced by North American Instruments, Inc.



The new units—weigh 2¼ lbs. and measure 4 in. in diameter by 5 in. high making them ideal for use in collecting aerodynamic data from missiles too small for conventional telemetering equipment.

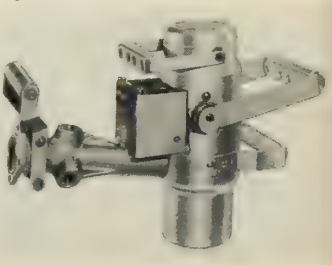
According to E. Bollay, NAI president, a single recorder has been recovered and reused eight times in missile tests to date at Holloman AFB, N. Mex. In all, company officials say some 12 different firms are using the units in rocket and missile testing.

Circle No. 213 on Subscriber Service Card

ACID TRANSFER NOZZLE

A missile oxidizer transfer nozzle developed by Lear, Inc., Lear-Romec Division, is designed especially for handling fuming nitric acid and is rated for operation at temperatures extending from —65° to +140°F.

The Romec nozzle, designated Model RR13110, meets requirements of Spec. MIL-N-25556 and uses only the purer aluminums and special stainless steel alloys to resist the corrosive action of HNO_3.



Normally, two nozzles are needed to transfer liquid propellants or oxidizers from the supply tank to the missile—one for filling and the other for venting the tank. The Lear nozzle provides a teflon gasket flange to which the vent or fill hoses are attached.

The Model RR13110, which is rated to handle a flow of 100 gallons per minute, incorporates two safety interlocks in its construction. The first prevents inadvertent opening of the flow control valve before the nozzle is attached and locked to the adapter on the missile tank: the second prevents unlocking nozzle from adapter while the flow valve is open.

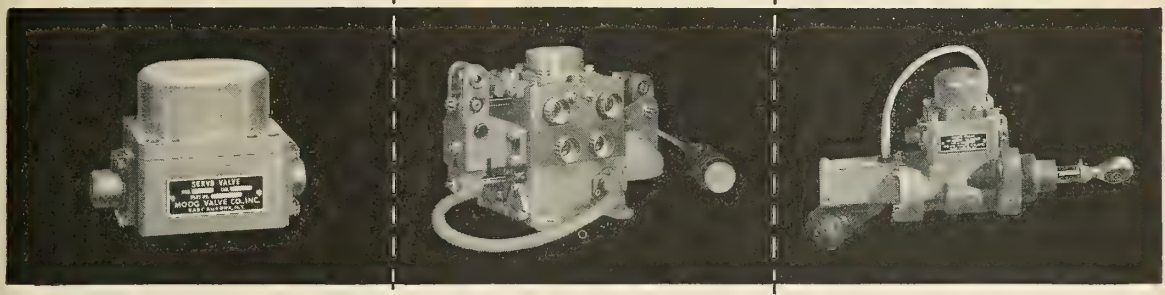
Lear-Romec also produces Model RD13040 adapters used on the missile tank and servicing trailer in conformance to Spec. MIL-A-25555. Literature available.

Circle No. 209 on Subscriber Service Card

From MOOG . . . **Advanced Electro-Hydraulic Servo Components**

Moog is the industry's leading producer of electro-hydraulic servo valves. This leadership has been achieved by advanced valve design resulting in high performance, high quality, reliability and efficient manufacture. The same creative approach applied to industry's newer problems has resulted in the introduction of Moog Dual Input and Servo Actuator units.

These recent achievements in the creation of advanced custom designed electro-hydraulic servo components are evidence of Moog's continuing progress.



SERVO VALVE

• These proportional "dry motor" electro-hydraulic servo valves feature high dynamic response, sensitivity, linearity and reliability. Light-weight and compact, they are also available in custom designed versions for special or advanced applications.

DUAL INPUT SERVO VALVE

• This new component provides for positioning of aircraft control surfaces by summing mechanical and electrical inputs without external use of mechanical linkages. Use of an entirely new concept offers improved performance, system simplification and saving of space and weight.

SERVO ACTUATOR UNIT

• Custom designed integrated assemblies include actuating cylinder, electro-hydraulic servo valve and feedback sensing device. In a closed loop, actuator displacement is a function of input signal.

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Axiomatically, to get somewhere in a hurry, you get aboard something that moves pretty fast.

If your "somewhere" is a career in engineering, consider Moog. From three founders to five hundred employees within five years, we are today the industry's leading manufacturer of advanced electro-hydraulic servo components. Our engineers made this possible by continuous pioneering of the new and successful developments in the field. As our rapid expansion continues, we have many openings at all levels for qualified personnel.

Best time to get aboard is now.

MOOG

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Research Laboratory, Paramus, New Jersey

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transistorized, plug-in modules for precision measurements of dc, ac, ohms and ratios

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Fully transistorized circuits in the new modules provide

1. Increased reliability.
2. Reduced power consumption.
3. Low heat dissipation.
4. Miniaturized packages.
5. Elimination of radio noise and line transients.

New specifications and features

1. Wider dynamic range covering all voltages from **100 microvolts to 1,000 volts,** resistance range from **10 milliohms to 10 megohms**—in **single** instruments!
2. Input power frequencies from **50 to 400 cycles!**
3. New balance logic speeds down ranging!
4. Automatic ac ranging from 30 to 10,000 cycles!
5. Controlled stepping switch drive increases switch life by a factor of **three!**

Complete flexibility

1. Universal 3½" x 19" x 12" chassis with mounting hardware for **any** rack.
2. **No** modifications required for operating printers, IBM Punches, etc., or for combining with auxiliary E-I input modules or instruments.
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4. With auxiliary plug-in modules, digitized data is provided in printed form, punched cards or tape with **no** modification to basic measuring instruments.

Circle No. 44 on Subscriber Service Card.

BASIC MODULES



Universal Power Module, Models DXA-000 or DXB-000

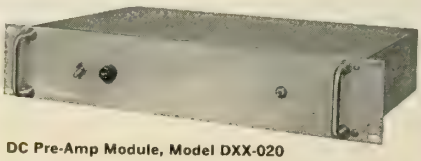
Supplies *all* power and reference voltages for other E-I modules. Power and reference supplies and stepper drive amplifier are transistorized. Powers one or more modules.

Calibration: Automatic
Reference Stability: 0.01% from 40° to 125° F.
Input Power: 115 volts, 50 to 400 cycles.
Write for Bulletin 175-1



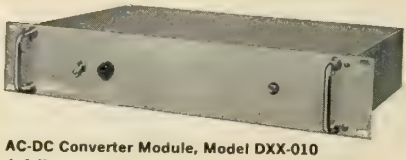
DC Switch Module
Model DVX-400: 4 digits; **Model DVX-500:** 5 digits

Contains Digital Potentiometer. Provides visual in-line read-out of digits, polarity, decimal point. All contacts accessible at rear panel connector. Front and rear panel input connectors. Power supplied by Universal Power Module.
Write for Bulletin 175-2



DC Pre-Amp Module, Model DXX-020

Input: 1 range scale, gain of 10.
Output: 0.0001 to .9999 volts. **Linearity:** 0.01%.
Gain Multiplication Accuracy: 0.01%.
Input Power: 115 volt, 50 to 400 cycles.
Drift: 10 microvolts per hour.
Write for Bulletin 175-5



AC-DC Converter Module, Model DXX-010

A fully transistorized AC-DC converter.

Accuracy: 0.1% of reading, or 2 mv.
Frequency Response: 30 to 10,000 cycles.
Range: .0001 to 999.9 volts.
Zin, AC: 1 meg. on the 1 volt scale, 10 megs. on other scales; 20 mmf.
Ranging: Automatic. **Reading time:** 3 seconds, average.
Write for Bulletin 175-4



Resistance Switch Module
Model DOX-400: 4 digits; **Model DOX-500:** 5 digits

Contains balance circuit, bridge ratio arms. Provides visual in-line read-out of digits, range. All contacts accessible at rear panel connector. Power supplied by Universal Power Module.
Write for Bulletin 175-3

Using E-I's new, transistorized, modular design, any precision instrument for measuring DC, AC-DC, Ohms, DC and AC ratios can be constructed from basic units!



DC Digital Voltmeters

specifications	**Model DVA-400** (Combines Universal Power Supply, Model DXA-000, and Model DVX-400 Modules.)	**Model DVA-500** (Combines Universal Power Supply, Model DXA-000, and Model DVX-500 Modules.)
Display:	4 digits, plus or minus, decimal point.	5 digits, plus or minus, decimal point.
Accuracy:	±1 digit.	±0.01%, plus or minus 1 digit.
Range:	.0001 to 999.9.	0.0001 to 999.99.
Automatic Features:	Ranging, polarity.	Ranging, polarity.

(Adding the E-I Pre-Amp Module, Model DXX-020, increases sensitivity to 10 microvolts.)

DC RATIOMETER – Same modules as Voltmeter except uses external reference. Ratio range: 0.0000 to 1.0999.



AC-DC Digital Voltmeters

specifications	Model DVA-410	Model DVA-510
DC Specifications:	Same as Model DVA-400.	Same as Model DVA-500.
AC Specifications:	Same as Model DXX-010.	Same as Model DXX-010.

(AC RATIOMETER combines Model DVA-400, with two Model DDX-040 or Model DXX-050 Modules. Ratio range is 0.0000 to 1.0999.)

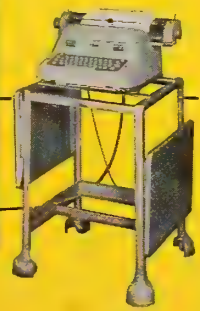


Digital Ohmmeter

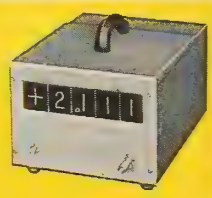
specifications	Model DOA-400 (Combines Model DXA-000 and DOX-400 Modules.)	Model DOA-500 (Combines Model DXA-000 and DOX-500 Modules.)
Display:	4 digits.	5 digits.
Range:	Automatic, 0.01 ohms to 10 megohms.	Automatic, 0.01 ohms to 10 megohms.
Accuracy:	0.01 to 0.1%.	0.01 to 0.1%.



OPERATING MACHINE READ-OUTS
Pictured here is a typical Automation System constructed with standard E-I modules. This system automatically scans and measures 400 channels of AC and DC voltages with punched tape read-out. E-I Model 200 X-Y Recorder provides plotted data. With auxiliary plug-in input and output modules, complete custom data handling systems may be set up. Write for Bulletin 175-6.



NEW HAND-CARRY MODEL
The Mark IV is the ideal companion to the new E-I rack-mounted modular equipment. Compact, weighs only 25 lbs.; 0.05% accuracy. Write for Bulletin 170.



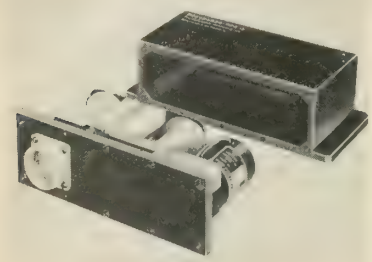
SEE THIS EQUIPMENT AT THE IRE SHOW, BOOTH #3614.

ELECTRO INSTRUMENTS INC. 3794 Rosecrans, San Diego, California

NEW LITERATURE AVAILABLE—Write for new short form Bulletin 175 containing information about the new Electro Instruments modular design.

MULTI-CHANNEL PROGRAMMER

A small programming device, the MPR-13, provides up to 13 channels for electrical programming of either repeat or random cycling. Weight is 3 lbs. 10 oz. and size is 2 x 3 x 6 inches. The device uses a moving insulating tape marked lengthwise in time and divided into 13 channels through punched holes and slots in the tape.



As the tape is advanced contactors close for a period equal to hole size or slot length. A magnesium casting is used for low weight and high resistance to shock and vibration. The Photographic Products, Inc.

Circle No. 217 on Subscriber Service Card

MICROWAVE DIODE

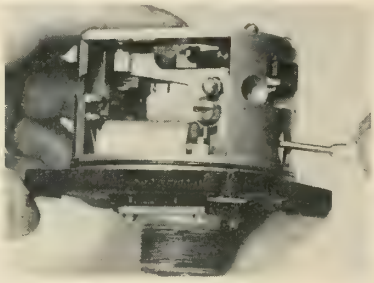
A silicon diode for use as a low-level detector in missile guidance, beaconing and telemetry has a theoretical tangential sensitivity of —53 dbm at 9000 mc for a receiver bandwidth of 10 mc.

Use of the MA-408B is said to give an improvement of 4-5 db when it replaces IN23C mixer crystals in low-level circuitry. For highest sensitivity a dc bias of +50 microamperes is recommended. The Microwave Associates, Inc.

Circle No. 216 on Subscriber Service Card

ACCELEROMETER

An accelerometer which has a caging mechanism to prevent wear when the unit is not in use offers accuracy to ½% and an operating temperature range from —50°C to 100°C. The caging mechanism of the new Series LA07-0100-1 is electrically released when it is in use.



Vibration from 10 to 2000 cps to 10g can be withstood and the device is shock-resistant to 40g or to 100g on special order. Rated linearity is 0.5 to 1.0%. Potentiometer pickoff is 500 to 20,000 ohms, and resolution to 0.15% is obtained. Humphrey, Inc.

Circle No. 218 on Subscriber Service Card

TRANSISTORIZED INVERTER

A dc to ac inverter with no moving parts has been designed to provide 300 va using transistors. Weighing 5.5 lbs. and occupying a volume of 96 cu. in. the new CW-1029 will withstand vibrations of 10g between 10 and 2000 cps.

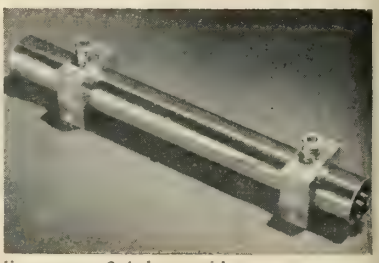
Use of the inverter is planned in the second stage of the Vanguard vehicle as a power supply for servos. Efficiency is rated as 60-70% with a harmonic content of less than 5%. Cooling is through the mounting base of the unit. Stability is within 0.2 cycles. The Electrosolids Corp.

Circle No. 215 on Subscriber Service Card

TRAVELING-WAVE TUBES

A new line of lightweight traveling wave tubes cover the range of 8-12 kmc and weigh 5-7 lbs. Weight includes a combined capsule and solenoid that reduces overall size and weight as well as minimizing power requirements for the solenoid.

Two of the eight tubes in the new



line cover 2-4 kmc with power outputs from 10 to 30 dbm and small-signal gains from 28-34. Two other tubes cover 4-8 kmc with 10-30 dbm outputs and signal gains of 30-32. Two others cover 8.2-12.4 kmc with outputs of 20-30 dbm and gains of 25-30. A similar series of tubes without the encapsulated solenoid have weights from 10¾ lb. to 20¾ lb. Geisler Laboratories.

Circle No. 221 on Subscriber Service Card

*LOX GRADE KEL-F**

Unsurpassed resiliency at—320°F is offered in our especially processed Kel-F* for rocket and missile seals. Sheets and tubes to 18 inch diameter are available, exhibiting unusual clarity and a minimum of cold flow throughout the ambient range.

Our engineering department is available to work with you on your Kel-F* and Teflon** problems.

We are approved to work under all military and commercial specifications.

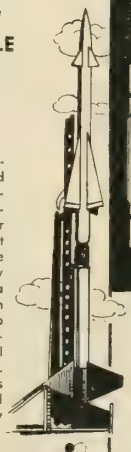
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UNEQUALED PERFORMANCE IN

- **TELEMETERING**
- **GUIDED-MISSILE MONITORING**
- **RADIOSONDE RECEPTION**

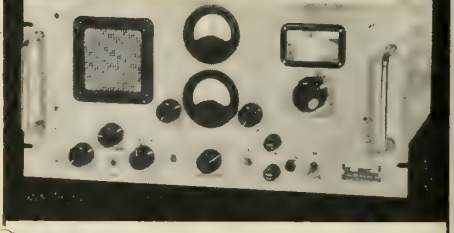
This Special Purpose Receiver is an improved version of the NEMS-CLARKE 167-J1 and 167-J2. This new Receiver incorporates the best qualities of both of the former types plus many new features including a BFO. A video bandwidth control is provided to greatly improve signal-to-noise ratio when full bandwidth is not needed. It is especially useful as a high quality general purpose laboratory receiver.



NEMS-CLARKE
INCORPORATED
919 JESUP-BLAIR DRIVE
SILVER SPRING, MARYLAND

For further information write Dept. H-11

TYPE 1501 SPECIAL PURPOSE RECEIVER



SPECIFICATIONS

Type of reception	AM, FM, or CW
Tuning range	55-260 mc
IF bandwidth	300 kc
Sensitivity (measured without band-restricting filters)	8 uv produces at least 23 db S/N ratio with 100-kc deviation, 400-cycle modulation.
Noise figure	11 db, maximum
IF rejection	Not less than 70 db
Image rejection	Not less than 40 db below 130 mc; 30 db minimum at any frequency.
FM output	0.15 volt per kc deviation (Approx.)
AM output	12 volts for 10 uv input modulated 30% at 1000 c.p.s. (Approx.)
Squelch	Operates on monitor circuit

Circle No. 45 on Subscriber Service Card.

Getting Talos Off to a Good Start



DESIGN
ENGINEERING
DEVELOPMENT
PRODUCTION

For its initial flight, the XX*-ton Talos ram-jet missile is pushed skyward by a powerful booster rocket. In a split second from launching, internal pressures are up to XXXX* psi . . . nozzle temperatures to XXXX* F. To design and produce a unit to endure such sudden torture called for an unusual combination of specialized engineering and fabricating skills. A major responsibility for the Talos rocket case was assigned to The M. W. Kellogg Company

Since 1951, M. W. Kellogg has been closely associated with the development and production of propulsion units for a wide range of missiles. Kellogg's most recent contribution is the development of reinforced plastic for rocket cases, using a unique filament winding method which produces structures of unparalleled accuracy and light weight.

*Actual figures classified

FABRICATED PRODUCTS DIVISION

THE M. W. KELLOGG COMPANY

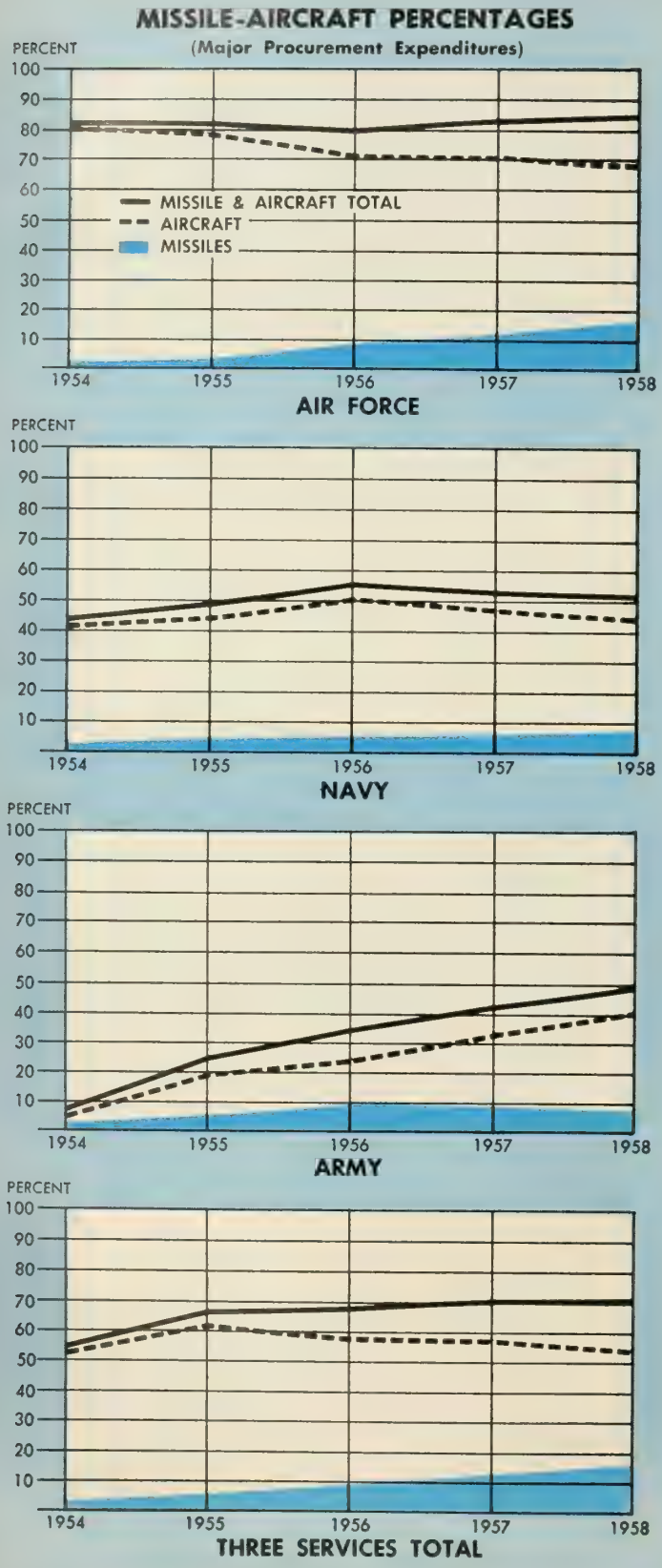
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M KELLOGG W

INDUSTRY BAROMETER



An analysis of Defense Department expenditure estimates reveals that in fiscal 1958 about 17 per cent of major procurement and production funds will be spent for guided missiles. Thirteen per cent will go for missiles during fiscal 1957.

During FY 1956, approximately $10 out of every $100 spent by the three services for major procurement and production was for guided missiles. In 1951, the rate was only $.50 out of every $100.

Of the three services Army has had the greatest growth in missile expenditures. Spending for missiles equalled 25 per cent of major procurement expenditures in 1956, and in 1958 missiles will account for 41 per cent. The 1956 missile expenditure percentages for the Navy and Air Force were 5 and 9 per cent, respectively; and in 1958 they will be up to 7 per cent and 17 per cent, according to DOD estimates.

Major procurement and production expenditures include, in addition to guided missiles and aircraft and related procurement, money paid out for ships and harbor craft; combat vehicles such as tanks, infantry assault and armored vehicles; support vehicles—trucks, ambulances, busses; artillery, including anti-aircraft; weapons; ammunition; electronics and communications equipment such as radar, radiac and infrared, and meteorological equipment; and production equipment and facilities. Other items not classified elsewhere, but whose size, unit value, or procurement and production problems indicate inclusion under the general category of major procurement and production, are also accounted for in this category. Such items are railroad equipment, major materials handling equipment, construction equipment and special training devices.

Guided missiles, as a part of the major procurement category, include, in addition to the complete missile with integral armament components, expenditures for the following: launching, guidance and control devices, boosters and sustainers; propellants (other than standard petroleum fuels); special tools and ground handling equipment peculiar to the handling of missiles; unmanned aerial targets, excluding target drones used primarily for training. The missiles category excludes standard aircraft engines not procured for use on guided missiles, and missiles and components for research and development or still in the research and development stage.

how would you seal it?



Answer: The *Gask-O-Seal® at right.

When you have a static sealing design problem why not find out how Franklin C. Wolfe Company's free design service can be of assistance.

FRANKLIN C. WOLFE CO.

"Sealing design specialist"

Culver City, California

* patent 2,717,793

Bell Applies New Microwave Power Find

First successful application of a recently discovered new source of microwave power has been achieved by Bell Telephone Laboratories.

Using what is known as the "maser" principle, a new electronic device using solid-state materials for radio energy generation and amplification was operated at Bell's Murray Hill Laboratories.

The "maser" was first demonstrated in molecular beams of gases in 1954 by Prof. C. H. Townes at Columbia University.

It means "microwave amplification by stimulated emission of radiation." The principle makes use of spinning electrons in a solid cyrstalline substance in the field of a strong electro-magnet.

Equipment used by Bell included a waveguide cavity containing the crystal. The whole assembly was immersed in liquid helium. The cavity has two resonant frequencies.

One was equal to the frequency of oscillation and the other to the energizing source. The crystal, paramagnetic salt diluted with a diamagnetic substance to reduce electron interaction, was located at the point of maximum field intensity—2,800 oersteds.

When a 17,500-mc energizing signal at about 100 milliwatts was brought into the cavity, the spinning electrons underwent a transition from one energy state to another and self-sustained oscillations occurred at 9,000 mc. Power output was 20 microwatts.

Bell scientists say the new oscillator has an attainable noise figure hundreds of times lower than presently available devices. This could result in development of new long distance communication systems.

In such uses the device could be easily tuned by varying the applied magnetic field and bandwidth would be around 100 mc.

AIA Hits Congress' Report On Recruitment

Aircraft Industries Assn., in a sharp rebuttal to Congressional criticism of costs in aircraft and missile engineering procurement, has charged that Navy Department figures were erroneously interpretated by a House group in arriving at its statistics.

Directing its comments at a report issued by the House Subcommittee on Manpower Utilization and Departmental Personnel Management, AIA officials explained that the fault rested with subcommittee calculations which based recruiting costs on net hires rather than on the Navy's system of gross hires.

Proper adjustment of figures cited by subcommittee chairman, Rep. James C. Davis (D-Ga.), would scale Davis' average cost of $1,317 per new employe down to the Navy figure of $808, AIA pointed out.

Citing an extreme example of the inconsistency of Congress approach, AIA asked what cost per new employe would be used if a firm spent $10,000 to recruit 10 new employes and in the same period lost 10.

The industry association also took issue with a comparison by chairman Davis of defense contractors and commercial business firms leading to a conclusion that the former spent more than 10 times as much for recruiting. AIA simply noted that the Congressman unfairly balanced the recruiting costs of 37 defense contract firms against similar costs of only 17 commercial firms.

Concluding its criticism, AIA noted that Congress took no testimony from industry in its investigation and urged that it confer with industry before launching any "corrective" program, as such action could have serious effects on the overall defense program.

Student Engineer Program Launched At Fairchild

Fairchild Engine Division, Fairchild Engine and Airplane Corp. has launched a cooperative student engineer program involving six major engineering schools to help alleviate the shortage of trained engineers.

The program is arranged to combine, in a five year span, four years of college education and two years of actual experience in aircraft powerplant design and development. Schools associated with the Fairchild program are Univ. of Cincinnati; Univ. of Detroit; Antioch College; Georgia Tech; Drexel Institute and Northeastern University. Project at Fairchild is being coordinated by T. F. Hammen, Jr.

Acme Gets AMC Award

Acme Precision Products, Inc. of Dayton, O. has received a $5,888,851 contract from Air Materiel Command for a new liquid oxygen plant.

EMPLOYMENT

ELECTRO-MECHANICAL ENGINEER

ICBM NOSE CONE DEVELOPMENT

PRESSURE SYSTEMS

SALARY to $11,000

The Missile & Ordnance Systems Department of General Electric, prime contractor for the development of the ICBM and IRBM nose cones, has an opening of unusual potential on its staff.

Required: ME, EE, or physics graduate with 5 to 10 years' experience in design, development and evaluation of barometric switches and pressure probes as applied to ordnance and missile systems.

Responsibilities: technical direction, functional leadership and project integration of three to eight engineers.

The environment is completely technical and professional. We are a research and development laboratory affiliated with one of the world's largest, most diversified and progressive industrial organizations. We hold prime contracts of a long-term nature with all of the armed services. Salary and benefits are liberal. Philadelphia location. Excellent facilities and equipment.

The Manager of our Arming and Fuzing Component Equipment Design Operation would be pleased to review your resume. A personal interview with him in Philadelphia will be arranged at our expense if your qualifications are appropriate. If you prefer, you need not reveal the name of your present employer.



Please write to
Mr. John Watt, Technical Recruiting, Room 575-3
MISSILE & ORDNANCE SYSTEMS DEPARTMENT

GENERAL ELECTRIC

3198 Chestnut Street • Philadelphia 4, Pa.

An Announcement

OF FIRST IMPORTANCE TO EXPERIENCED ROCKET ENGINEERS AND SCIENTISTS

- *Reaction Motors initiating big new Research and Development Program*
- *Key spots offered to men who have already made a name for themselves in Rockets*

If you're one of the relatively few trained rocket men in America, your experience will pay off handsomely at Reaction Motors. The first rocket company in America, RMI is now entering its period of greatest expansion, a period that will see far-reaching developments in America's fastest-growing industry. Your participation in RMI's program during this crucial period is your best guarantee of leadership in the industry. In a job like one of those listed below you'll be strategically placed for both achievement and advancement.

1. Senior Design Engineer

Prefer ME or AE degree and a minimum of 6 years experience in aircraft engines or airframes. You should have extensive design experience, including plenty of board time, shop contact, structural design, stress analysis. You will be working directly with design engineers and layout draftsmen on design of light weight, complex structures.

2. Instrumentation Engineer

BS minimum in mechanical, aeronautical or electrical engineering; 3-5 years experience on aircraft engines. Must be familiar with the application of instrumentation to testing of rocket or other aircraft engines, the utilization of currently available instrumentation, or the modification and adaptation of such instrumentation for particular requirements and wide limits of flow temperatures, pressure, thrust, etc.

3. Stress Engineer

Degree in engineering or applied mechanics. Required experience in mechanical design with emphasis on stress analysis: 3 years for an engineer, to 6 years for the senior engineer. Must be able to handle and/or supervise involved analyses—including the effects of dynamic forces, high temperature gradients and high pressure differentials—under conditions where light weight is vital.

4. Project Engineer

BS or MS in ME, AE, or ChE—with at least 5 years experience in the design, fabrication and test of rocket thrust chambers, gas generators and ignitors. Project engineers also needed with background which includes knowledge of principles and problems associated with design, development and analysis of hydraulic or pneumatic power plant controls and systems.

RMI'S 6 MAIN PROJECT AREAS INCLUDE:

MISSILES • PILOTED AIRCRAFT • LAUNCHING DEVICES • GROUND SUPPORT EQUIPMENT • LIQUID AND SOLID PROPELLANT CHEMISTRY • NUCLEAR ROCKETS

For additional information on these or any other positions, drop a note or send complete resume in strict confidence to:

SUPERVISOR OF TECHNICAL PLACEMENT

Power for Progress

RMI®

REACTION MOTORS, INC.

A MEMBER OF THE OMAR TEAM

50 FORD ROAD • DENVILLE, N. J.

HOW DO YOU GROW AT ARMA?

Through diversification!

In our recent advertisements, we spoke of the growth opportunities offered by Arma. Almost immediately, perceptive engineers began writing us, asking for more information.

"How *does* an engineer grow at Arma — precisely?"

Our answer, in a word, is *diversification.* Arma offers one of the *broadest programs of work diversification* in the electronics field.

At Arma, an engineer follows a project from original design, right through final production. As a result, our engineers and scientists are exposed to many activities not usually found under one roof — areas into which they can grow, as their abilities and interests lead them.

Here are some of the areas — 69 examples — in which Arma concentrates its efforts in:

MISSILE CONTROLS & GUIDANCE and FIRE CONTROL

1.0 SYSTEMS DEVELOPMENT
- 1.1 Digital Computers
- 1.2 Autopilots
- 1.3 Infrared
- 1.4 Electromagnetic Devices
- 1.5 Gyroscopics
- 1.6 Inertial Platforms
- 1.7 Missile Guidance
- 1.8 Fire Control
- 1.9 Servos

2.0 PROJECT ENGINEERING
- 2.1 Airborne Fire Control
- 2.2 Airborne Armament
- 2.3 Air-to-Air Missiles
- 2.4 Semi-Automatic Test Equip.
- 2.5 Air Traffic Control
- 2.6 Optical Systems
- 2.7 Stabilizing Devices
- 2.8 Submarine Fire Control
- 2.9 Electronic Test Equipment

3.0 SYSTEMS EVALUATION
- 3.1 Instrumentation Evaluation
- 3.2 Telemetry
- 3.3 Data Reduction
- 3.4 Data Analysis
- 3.5 Project Engineering
- 3.6 Data Process Planning
- 3.7 Control Circuitry Design

4.0 SYSTEMS ENGINEERING
- 4.1 Trajectory Analysis
- 4.2 Airframe Performance
- 4.3 Weapons Control
- 4.4 Operations Research
- 4.5 Radar
- 4.6 Error Analysis
- 4.7 Reliability

5.0 COMPONENTS
- 5.1 Transistors
- 5.2 Magnetic Amplifiers
- 5.3 Synchros
- 5.4 Tachometers
- 5.5 Accelerometers
- 5.6 Resolvers
- 5.7 Integrators

6.0 RADAR
- 6.1 CW Doppler Systems
- 6.2 Antenna Design
- 6.3 Components
- 6.4 Pulse Circuitry
- 6.5 Countermeasures
- 6.6 Laboratory Evaluation

7.0 PROJECT ADMINISTRATION
- 7.1 Project Planning & Control
- 7.2 Sub-Contracted Liaison
- 7.3 Contracts Evaluation
- 7.4 Project Coordination

8.0 DIGITAL COMPUTERS
- 8.1 Logical Design
- 8.2 Dynamic Analysis
- 8.3 Circuit Development
- 8.4 Component Development
- 8.5 Packaging
- 8.6 Field Evaluation

9.0 ENVIRONMENTAL
- 9.1 Vibration
- 9.2 Shock
- 9.3 System Test
- 9.4 Component Test
- 9.5 Materials Analysis
- 9.6 Dynamics

10.0 MISSILE GROUND EQUIP.
- 10.1 Operations Techniques
- 10.2 Count-down Equipment
- 10.3 Launching Control Instrumentation
- 10.4 Control Circuitry
- 10.5 Automatic Test Equipment
- 10.6 Console Integration
- 10.7 Remote Data Recording
- 10.8 Optical Monitoring

If you want to participate in the growth that *must* come to a man working in so diversified an environment, write and tell us the area in which you're most interested. (Or use the coupon below.) Your confidence will be respected, and you will hear from us promptly. If you prefer, forward confidential resume. No reference contact without your permission.

Technical Personnel Department M-674

ARMA

Division of American Bosch Arma Corporation
Roosevelt Field, Garden City, Long Island, N. Y.

Gentlemen:

☐ Please send me additional information concerning the job numbered _____

☐ Or, additional information concerning the area of _____
(state interest if not in above listing)

NAME _____

ADDRESS _____

CITY _____

ZONE _____ STATE _____

Missile School Marks 4th Year

HUNTSVILLE, Ala.—One of the nation's most important but least appreciated defense agencies is observing its fourth anniversary here this month by getting a new name and putting the Army's new *Lacrosse* surface-to-surface and *Dart* anti-tank missiles on public view for the first time. In fact, it exhibited the Army's whole family of missiles, except the late models of the IRBM and ICBM.

The Ordnance Guided Missile School—now the U.S. Army Ordnance Guided Missile School, by official decree—held an open house, showed movies, displayed its sleek weapons served cake and coffee—and even allowed cameras.

The School has been somewhat overshadowed in this area by the presence of its more spectacular sister installations, Redstone Arsenal and Army Ballistic Missile Agency.

Yet in four years it has provided the nation with the nucleus of its new missile defense units. More than 5,000 key officer and civilian personnel have been "graduated" from its courses in the use and maintenance of the *Nike Ajax, Corporal* and *Redstone* missiles and are now on duty with missile units in the field and at key headquarters.

They are the beginning of a vastly expanded program that will see thousands of men—and some women—trained to handle the increasingly potent and varied arsenal of missiles available to the Army and other branches of the service. A $7 million building program is under way to provide training in *Nike-Hercules, Dart, Sergeant* and *Lacrosse* missiles.

Navaho Cutback at NAA Forces Layoffs

Reduction by the Air Force of a portion of the second-stage test vehicle (X-10) in the *Navaho* missile program has resulted in a reduction in force at North American Aviation's Downey and Los Angeles *Navaho* activities.

However, a portion of the layoffs will be absorbed by attrition (not hiring replacements), and NAA said it will also attempt to re-assign employees who can qualify for job openings in other divisions.

The remaining layoffs, of undisclosed number, will be made by NAA in accordance with existing union agreements. The force reduction became necessary when the Air Force

rdered the company to divert ma-
rials from X-10 test vehicles to more
dvanced stages in *Navaho* missile de-
elopment, essentially introducing a
stretch-out" in the *Navaho* program.

Marquardt Aircraft Grants General Pay Hike

Marquardt Aircraft Co., producer f the ramjet powerplant for the Boe- g *Bomarc,* announced a general wage crease of 4% for salaried employes ffective on February 18. Hourly em- loyes also received a 7 to 12¢ per our pay hike.

The new increase, which affects bout 2,680 personnel, increases Mar- uardt's top technical and office hourly cale to $3.12 an hour and top factory rade to $2.93.

Culver City Quarters For Douglas Engineers

Douglas-Santa Monica division as shifted about 160 missile engineer- g personnel to new quarters at Doug- s A2 location in Culver City, Calif. s a result of the growth of missile ngineering work at Santa Monica.

Company is now constructing a ant balcony that will add 45,000 sq. . of office space for the division's issiles engineering department.

New GE Contract For J79s May Be For Regulus II

General Electric Co. has an- ounced receipt of a $53,414,557 Air orce contract for additional J79 jet ngines but did not identify the air- aft for which they are slated.

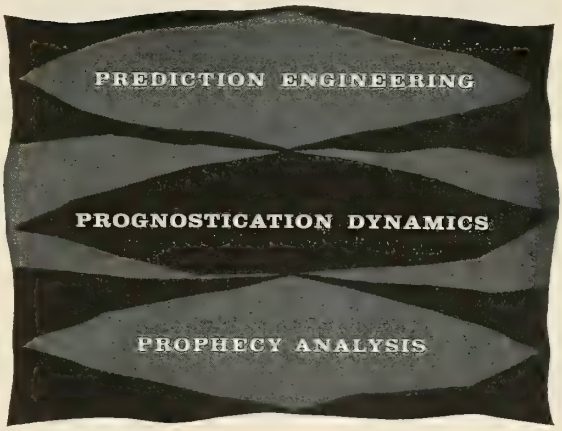
The J79 is presently used in the ockheed F-104A and Convair B-58 personic bomber, but is also known power the supersonic Chance ought Regulus II missile, a possible planation for the omission of air- aft mention in the announcement.

Douglas, Northrop Get Missile Contracts

Northrop Aircraft, Inc. has re- ived a $3,366,647 contract from Air ateriel Command covering flight sting of "undisclosed equipment" pre- med to be a missile.

Douglas Aircraft Co. at Sacra- ento, Calif. received a $1,305,528 MC award for guided missile (*Thor*) velopment work.

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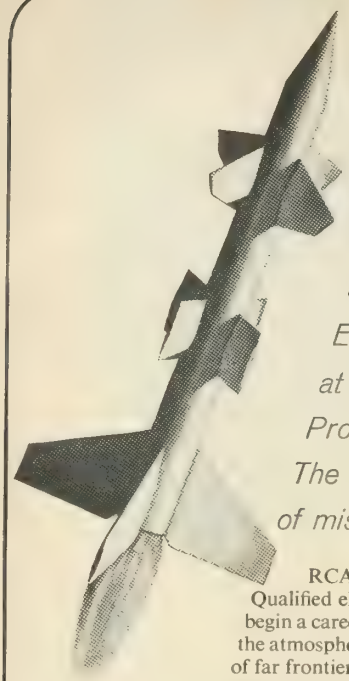
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Mr. George Hickman, Engineering Employment Manager

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Chrysler Transfers Personnel to ABMA

HUNTSVILLE, Ala. — Chrysler Corporation, which has been manufacturing limited quantities of the Army's Redstone short-range missile in its Detroit plants, is transferring 21 employes and their families to Huntsville, Alabama. Purpose of the move is said to bring specialized missile engineers into closer contact with the Redstone Arsenal and Army Ballistic Missile Agency here.

Local representatives of Chrysler would not comment on reports that the transfer of the group portends increased production here of the Redstone and other missiles. Heretofore, production of the Redstone missile has been equally divided between Detroit and Huntsville.

RMC Organizes Subsidiary Plant On West Coast

Rochester Manufacturing Co. of Rochester, N. Y. has set up an engineering and production subsidiary at Pasadena, Calif. to produce aircraft and missile high pressure gauges.

New firm, to be called Rochester Manufacturing Co. of California, will produce gauge equipment developed by Lindsay Engineering Co. of Pasadena. J. E. Lindsay, former research scientist at California Institute of Technology and inventor of the new gauge, will be manager of engineering for the RMC subsidiary.

A. H. Ottman, RMC president, said the west coast firm probably will be geared to assemble and store products manufactured in its three Rochester plants, including weapons fire control components.

New Missile Gear Firm Formed in Massachusetts

Geartronics Corp., new precision instrument gear firm located at 30 Nashau St., Woburn, Mass. has been formed as an outgrowth of the merger of Massachusetts Gear & Tool Co. and Gear Systems, Inc.

According to John H. Lyman, the firm's president, the consolidation will provide facilities for production of both precision and commercial gears, complete gear systems and gear research and development for industrial and military applications.

Prior to the merger, Gear Systems, Inc. played a major role in R&D activity for radar, aircraft, missile, computer and atomic energy applications. Heading research for the new firm is Prof. Earle Buckingham.

ormerly of the mechanical engineering department at Massachusetts Institute of Technology.

Martin Begins Shift into Denver Plant

The Martin Co. during February moved a starting group of 63 employes into its new Denver plant that is slated to build the *Titan* ICBM. Over the next several months, the company expects to install about 600 tools and major pieces of equipment into the facility and to vacate a temporary manufacturing plant in Denver.

To date, Martin contracts from the Air Force on the Titan project total $385 million.

Beckman Computers Ordered For *Thor, Titan*

Two new orders for computer and data processing equipment have been announced by Beckman Instruments, Inc. for major missile programs.

Douglas Aircraft Co. has an order with the Fullerton, Calif. firm for a 200-channel, Beckman 112 transistorized data-processing system to speed research on Air Force's *Thor* intermediate range ballistic missile.

Baldwin-Lima-Hamilton Corp. also took delivery of the first of a new series of transistorized special purpose analog computers designated the Beckman 101. Baldwin-Lima-Hamilton will use a total of 10 Model 101 computers as part of the instrumentation on test stands it is developing for Martin-Denver for the *Titan* ICBM project.

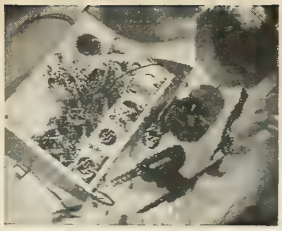
Both devices are being produced by Scientific Instruments Division of Beckman.

Bell To Expand R&D Program

Bell Aircraft Corp. is planning a $15 million expansion of its research and delevopment facilities including the construction of The Lawrence D. Bell Research Center on a 100-acre tract in Cheektowaga, N.Y.

Bell president Leston Faneuf, in a recent talk in Buffalo, said the center will include a hypersonic windtunnel and other facilities for thermal barrier research.

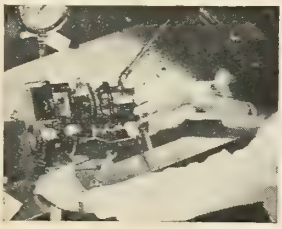
Expansion program at Bell also will include a new electronic computer and data processing center, a large engineering research building and a development manufacturing shop. These facilities will occupy 619,000 sq. ft.



TEST EQUIPMENT

The Test Equipment Engineer is engaged primarily in the design of specialized missile check-out equipment. As missiles push the state of the art, test equipment must exceed the missiles in precision and reliability. Automatic programing, go-no-go evaluation, and automatic data processing add up to automation in missile testing.

This engineer is evaluating his design of a precision power supply—one of the building blocks that will be system engineered into a family of versatile matched missile and sub-system test equipment. Engineers work as individuals.



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Many components, which a few months ago seemed almost impossible to design, are now being tested under the severe conditions required to qualify them for flight operation—and passing with flying colors.



STEERING INTELLIGENCE

Two Steering Intelligence Engineers discuss space allotment in a new guidance component. This close association of engineers with the "flying" equipment is typical of the Steering Intelligence Section. Engineers in this section are primarily *and directly* concerned with refining the guidance equipment to steer the missile with greater accuracy, at greater ranges and with simpler and more reliable electronic equipment and, consistently, with minimizing the cost. Work is actively in progress in every principal field from microwave equipment to inertial end instruments.

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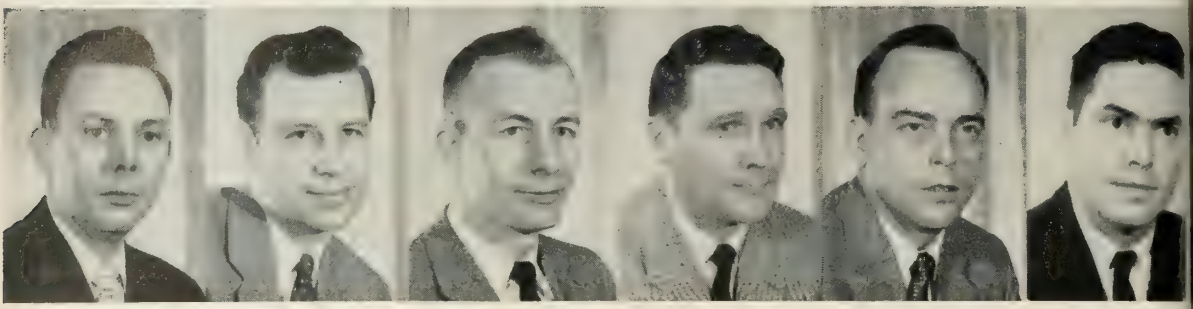
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Columbia U is Commended By GE for Defense Efforts

Columbia University's Electronics Research Laboratories have been commended by General Electric as a leading contributor to the nation's air defense capability. J. J. Farrell, General Manager of the G-E Heavy Military Electronic Equipment Department at Syracuse, said that certain basic computing, storage and display components used in a new ground control intercept system produced by his department for the Air Force were developed at Columbia's Research Laboratories under the initial direction of Dr. John R. Ragazzini, who is now Executive Officer of the University's Department of Electrical Engineering. Professor L. H. O'Neill, currently Director of the Electronics Research Laboratories, completed the development.

Mr. Farrell termed the development of the intercept system an outstanding example of "university-industry cooperation" aimed at the primary goal of promoting national security. Nomenclature for the overall system which includes the Columbia developed "Ragazzini Computer" is the AN/GPA-37 Radar Course Directing Group. The system is designed to receive data from long range radars, track the potential enemy aircraft and subsequently direct our interceptors to the target for the kill.

$2.4 Million Missile Awards By AMC

Largest of three new missile contracts awarded by USAF's Air Materiel Command went to Goodyear Aircraft Corp. and totaled $1,279,496 for *Matador* (TM-61B) missile guidance system facilities. GAC is prime contractor for both *Matador* guidance and ground handling equipment.

Other AMC contracts were awarded Aerojet-General Corp. ($266,882) for rocket boosters and igniters, and to Hughes Aircraft Corp. ($920,000) for *Falcon* missile facilities.

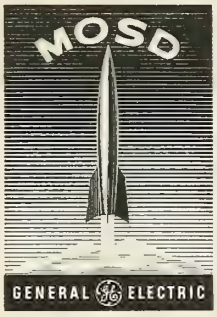
Ryan Gets New Contract For *Firebee* Drones

Ryan Aeronautical Co. has received two Air Force and one Navy contract totaling $5,350,000 to produce more than 100 additional *Firebee* jet target drones. The *Firebee* is now in use at USAF's Vincent AFB, Ariz.

Ryan officials said that other contracts expected soon will extend *Firebee* production to mid-1958. Company is also developing an advanced version of the drone for USAF to enable it to reach higher speeds and altitudes.

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ing Corp., producer of the J69 jet engine for the *Firebee*, disclosed that a Ryan XQ-2B drone has achieved an altitude of 53,500 ft. during tests at Holloman AFB, N. Mex. Drone was recovered by parachute after 97 minutes of powered flight.

Positions Available in U.S. IGY Satellite Tracking

The Astrophysical Observatory of the Smithsonian Institution, 60 Garden Street, Cambridge 38, Massachusetts, is accepting applications from scientists and technicians for positions in the Optical Satellite Tracking Program of the IGY. Qualified personnel will be assigned as observers to IGY stations in the United States, and in foreign countries for periods from one to two years. Prior experience in physics, astronomy, or electronics is mandatory and an academic degree in one of these fields is desirable.

Interested persons should write to the Associate Director, Satellite Tracking Program, at the address mentioned above.

Elgin Gets $360,000 In New Nike Contracts

Recent $360,000 contract award to Elgin National Watch Co. for safety and arming mechanisms for Nike missiles has increased by more than 200% its production in that program, the company reports.

Elgin is presently working on three contracts for the electro-mechanical fuzing device which it recently redesigned under assignment from Diamond Ordnance Fuze Laboratories.

Republic To Build New Wind Tunnel

Republic Aviation Corp. has let a $200,000 contract with Burns and Roe, Inc., New York engineering and construction firm, to design and supervise construction of a new windtunnel facility for advanced aircraft and missile testing.

Project will involve two tunnels—a transonic facility covering speed ranges from Mach 85 to 1.4, and a supersonic tunnel for testing up to Mach 4)3,000 mph).

Tunnel facility will be housed in a 72 by 82 ft. building at Republic's Farmingdale, L. I. location. Total project will run about $1 million.

Firm of Burns and Roe previously was responsible for design of ground equipment for both the Bendix *Talos* and Boeing *Bomarc* missiles as well as the Naval Aero Turbine Test Station, Trenton, N. J.

missile literature

ANALOG COMPUTERS. New booklet entitled "High-Speed Analog Computers, Key to Rapid System Development," presents question-and-answer type description of a number of computer types and their application in development of control systems for military weapons, by GPS Instrument Co., Inc.

Circle No. 107 on Subscriber Service Card

MICRO SWITCHES. New 32-page catalog available from Micro Switch, a Division of Minneapolis-Honeywell Regulator Co. describes more than 140 switches, switch actuators and terminal enclosures it produces for airborne applications.

Circle No. 108 on Subscriber Service Card

SERVO MOTORS. Bulletin No. 385 issued by Norden-Ketay Corp. contains complete data on its standard and custom servo motors.

Circle No. 109 on Subscriber Service Card

BALANCING MACHINE. A 16-page booklet published by Stewart-Warner Corp. gives details on its electronic dynamic balancing equipment used for aircraft and missile jet engine rotors, impellers, gears and flywheels, etc.

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D-C MOTORS. Fractional Horsepower d-c motors built to Spec. MIL-M-8609 are illustrated in 8-page booklet by Lundy Manufacturing Corp.

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NICAD BATTERIES. Nickel cadmium batteries for aircraft and missile use are described in 8-page technical report prepared by Nickel Cadmium Battery Corp.

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SHOCK TUBES. Avco Manufacturing Corp. has published a 10-page brochure describing new services it offers in the design and manufacture of special shock tubes for aircraft and missile research. To date Avco has developed units capable of simulated speeds of Mach 25 at altitudes exceeding 100,000 ft.

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ROCKET FACILITIES. Four-page brochure describing facilities and past activities in solid-propellant rocket development is available from Grand Central Rocket Co.

Circle No. 101 on Subscriber Service Card

PROPELLANT-POWERED CUTTERS. New leaflet distributed by Propellex Chemical Corp. announced availability of its electrically-initiated, propellant-powered cutters for parachute risers and reefing cords.

Circle No. 102 on Subscriber Service Card

MINIATURE BEARINGS. New 16-page catalog lists RMB miniature ball and roller bearings produced in Switzerland and marketed in U.S. by Landis & Gyr, Inc.

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METALLURGICAL TESTS. Complete scope of metallurgical testing services available from Crippen & Erlich Laboratories, Inc., subsidiary of Foster D. Snell, Inc. are described in four page folder. Price list included.

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SILICONE REPORT. Laboratory report on its new fluorinated silicone compound for aircraft and missile fuel systems is available from Acushnet Process Co.

Circle No. 105 on Subscriber Service Card

MAGNESIUM/TITANIUM DATA. New 44-page booklet published by Brooks & Perkins, Inc. describes in detail the physical and mechanical properties of magnesium and titanium, including forming, welding, machining, heat treatment and stress relief characteristics.

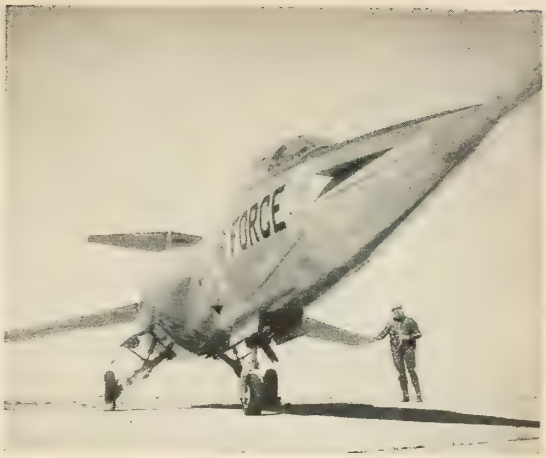
Circle No. 106 on Subscriber Service Card

INFRARED SYSTEMS. New 8-page brochure issued by Servo Corporation of America described company's infrared applications and research activities in producing and delivering some 21 such weapons systems to date.

Circle No. 120 on Subscriber Service Card

LOW TEMPERATURE APPARATUS. Hofman Laboratories, Inc. has published a 16-page catalog illustrating low temperature equipment it produces, including capacity and performance data on specific liquid oxygen and nitrogen handling units.

Circle No. 121 on Subscriber Service Card



Official U. S. Air Force photograph

Throws out electron tubes... keeps chopper

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Coil resistance:	85 ohms
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***Dissymmetry:**	Less than 4%
***Switching time:**	15° ± 5°
Temperature:	—55°C to 100°C
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*These characteristics based on sine-wave excitation.

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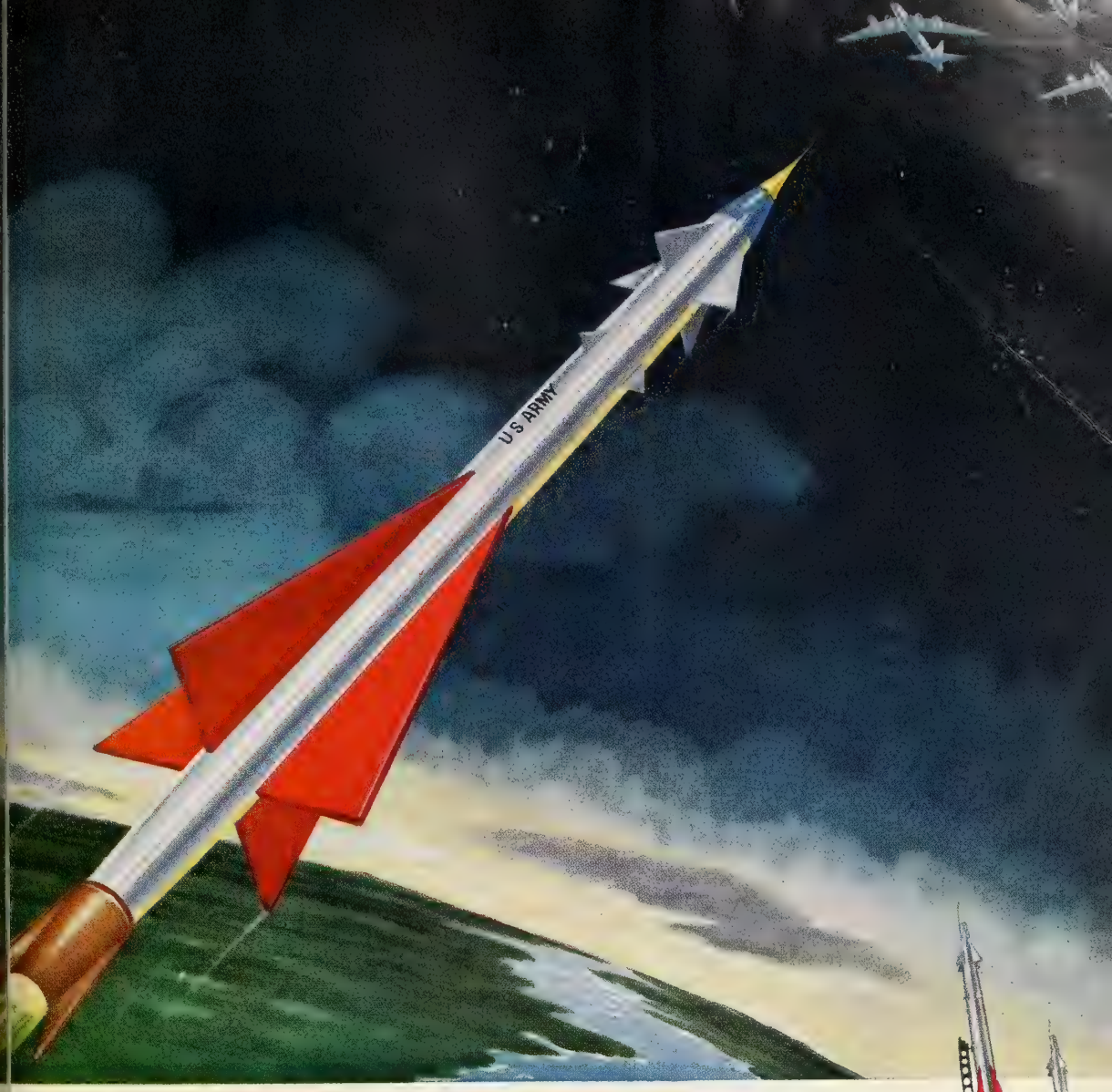
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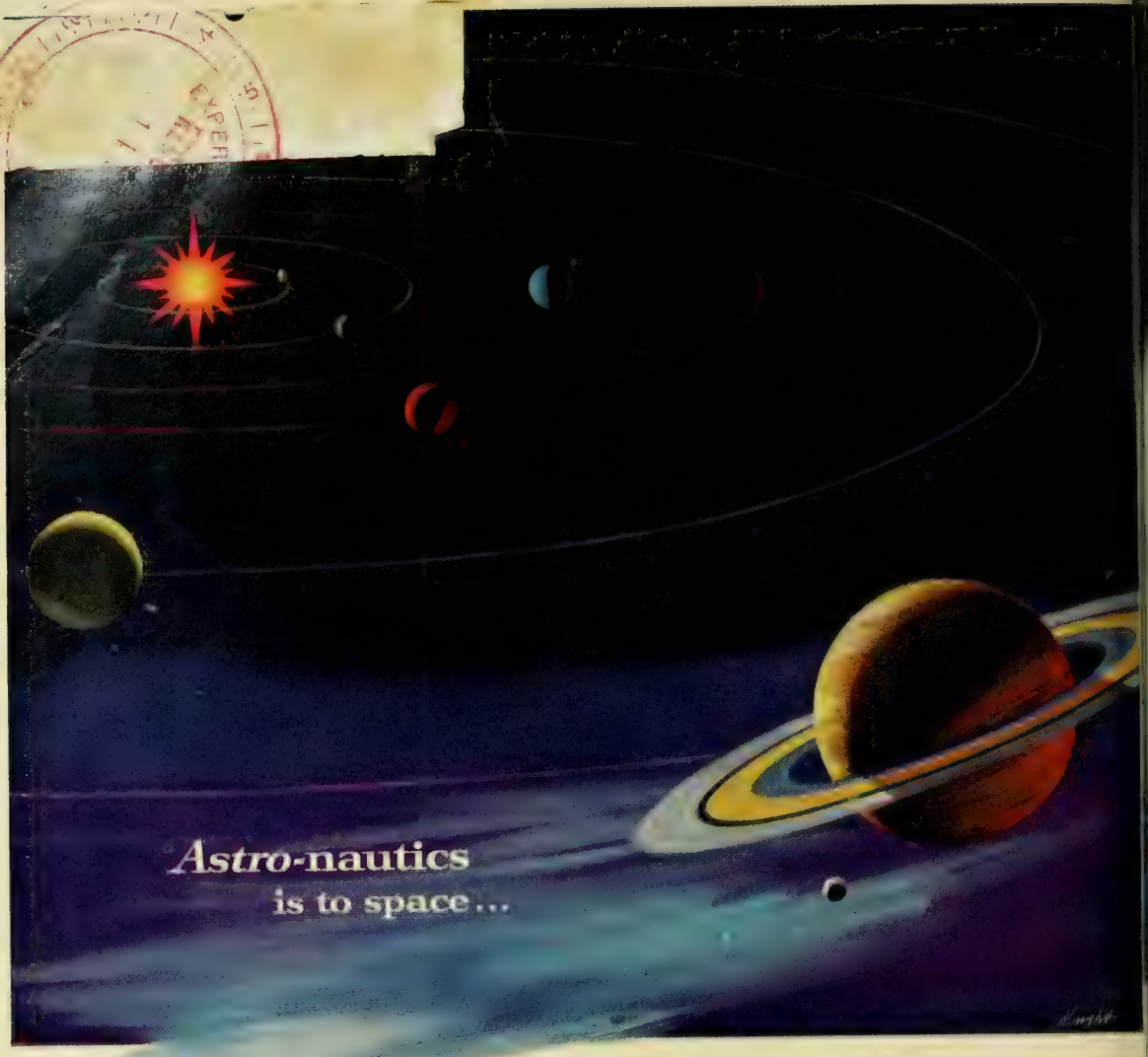




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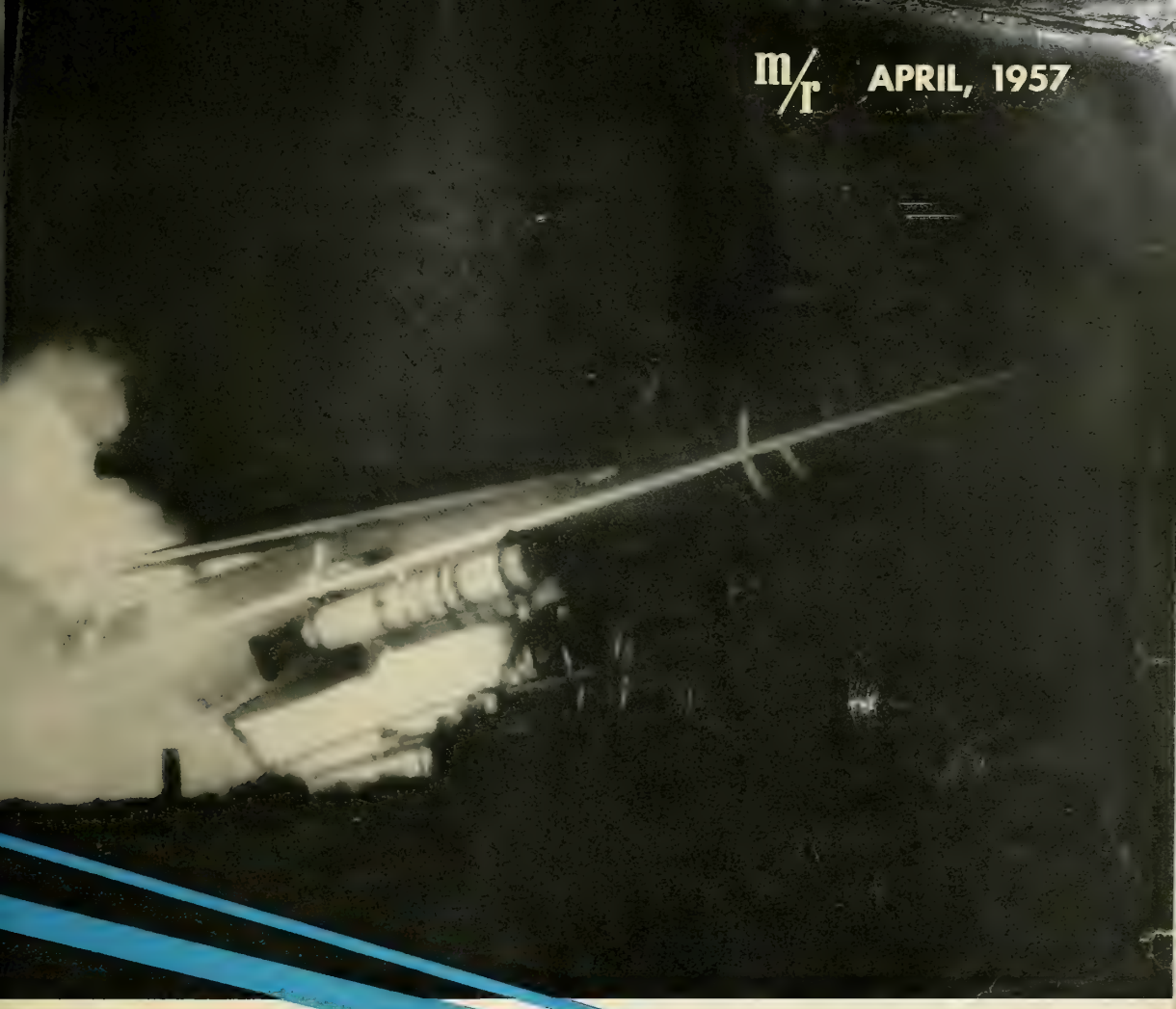
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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

This Issue:

US AIR FORCE LONG-RANGE MISSILE DEVELOPMENT

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The industry has long established the Mil Spec as a measuring stick of performance and quality. At Narmco, we too feel at home with Mil Specs.

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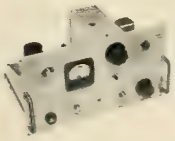
TECHNIQUES and DEVELOPMENTS
in oscillographic recording



FROM
SANBORN

PHASE SENSITIVE DEMODULATOR PREAMPLIFIER PROVIDES A DC VOLTAGE PROPORTIONAL TO AN INPHASE COMPONENT OF AN AC VOLTAGE WITH RESPECT TO A REFERENCE.

THE measurement of the amplitude of an AC voltage component is often necessary in performance studies of servo systems or of suppressed carrier signals over the carrier frequency range from 60 to 10,000 cps. In such cases the demodulator responds to inphase signals and rejects quadrature signals.

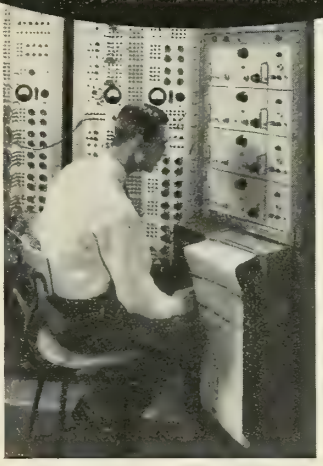


A circuit with these characteristics for use in an oscillographic recording system can be seen in the Model 150-1200 Servo Monitor (Demodulator) Preamplifier. It was developed by Sanborn as one of twelve interchangeable, plug-in front ends for "150" Series equipment, to be used with the appropriate Driver Amplifier-Power unit in any channel of a "150" system. Elements comprising the circuit from input to output, include: compensated stepped attenuator and cathode follower input circuit, phase inverter, push-pull mixer and demodulator stages, differential DC output amplifier and low pass filter. In addition, the chassis contains a VTVM to facilitate accurate adjustment of the reference voltage, and an overload indicator which lights a warning lamp when excessive quadrature voltages exist.

Adaptability to a fairly wide variety of applications is accomplished through broad input voltage, reference voltage and frequency ranges. In order, these are 50 mv to 50 v (for full scale 5 cm deflection), 10 v to 125 v; 60 cps to 10kc. Rise time with low frequency plug-in demodulation filter is 0.1 seconds; with high frequency filter, 0.01 seconds. Quadrature rejection is better than 100.1; for carrier frequencies up to 5000 cycles.

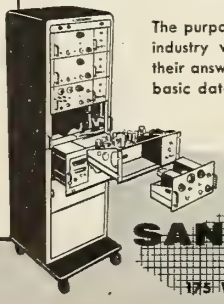
Two representative uses of the Servo Monitor Preamplifier are in the design and adjustment of servo systems, and with instruments used in the design, development or adjustment of other apparatus. The first is illustrated by use of the Preamplifier and associated equipment in the recording of the output shaft amplitude and driving frequency of an AC positional servo; the second by recordings made with a similar setup of the difference between output signals from a gyroscopically-controlled stabilizing device and the "pitch" and "roll" signals generated by a "Scorsby Table" used for testing the device under dynamic conditions.

For a detailed discussion of the principles and design considerations involved in the Servo Monitor Preamplifier, refer to the February, 1955 issue of the Sanborn RIGHT ANGLE, for Dr. Arthur Miller's article on "Measurements with the Servo Monitor Preamplifier."



BASIC FACTORS IN SELECTING OSCILLOGRAPHIC RECORDING EQUIPMENT

WHEN considering any oscillographic system or equipment for your application, three useful "yardsticks" to apply are (1) the recording method, (2) equipment adaptability, and (3) variety of equipment available. Here are the answers to the three, as they apply to Sanborn systems. In the record, rectangular coordinates accurately correlate multiple traces, simplify interpretation and eliminate errors. Permanent traces, produced by a hot ribbon stylus without ink, provide sharp peaks and notches, and clearly reveal all signal changes. One percent linearity results from current feedback driver amplifiers and high torque galvanometers of new design; maximum error is ¼ mm in middle 4 cm of chart, ½ mm across entire chart. From the standpoints of "adaptability" and "variety", Sanborn "150" equipment offers the versatility of 13 different plug-in front ends for any basic system . . . the choice of one- to eight-channel systems . . . the variety of nine chart speeds, timing and coding controls, console or individual unit packaging . . . availability of equipment as either complete systems or individual amplifier or recorder units.



The purpose of the foregoing information is to better acquaint industry with typical oscillographic recording problems and their answers, design considerations in Sanborn equipment, and basic data on what Sanborn makes and how it is being used.

Technical literature and engineering assistance on specific problems are always available from our engineering department.

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Magazine of World Astronautics

April, 1957 Volume II, No. 4

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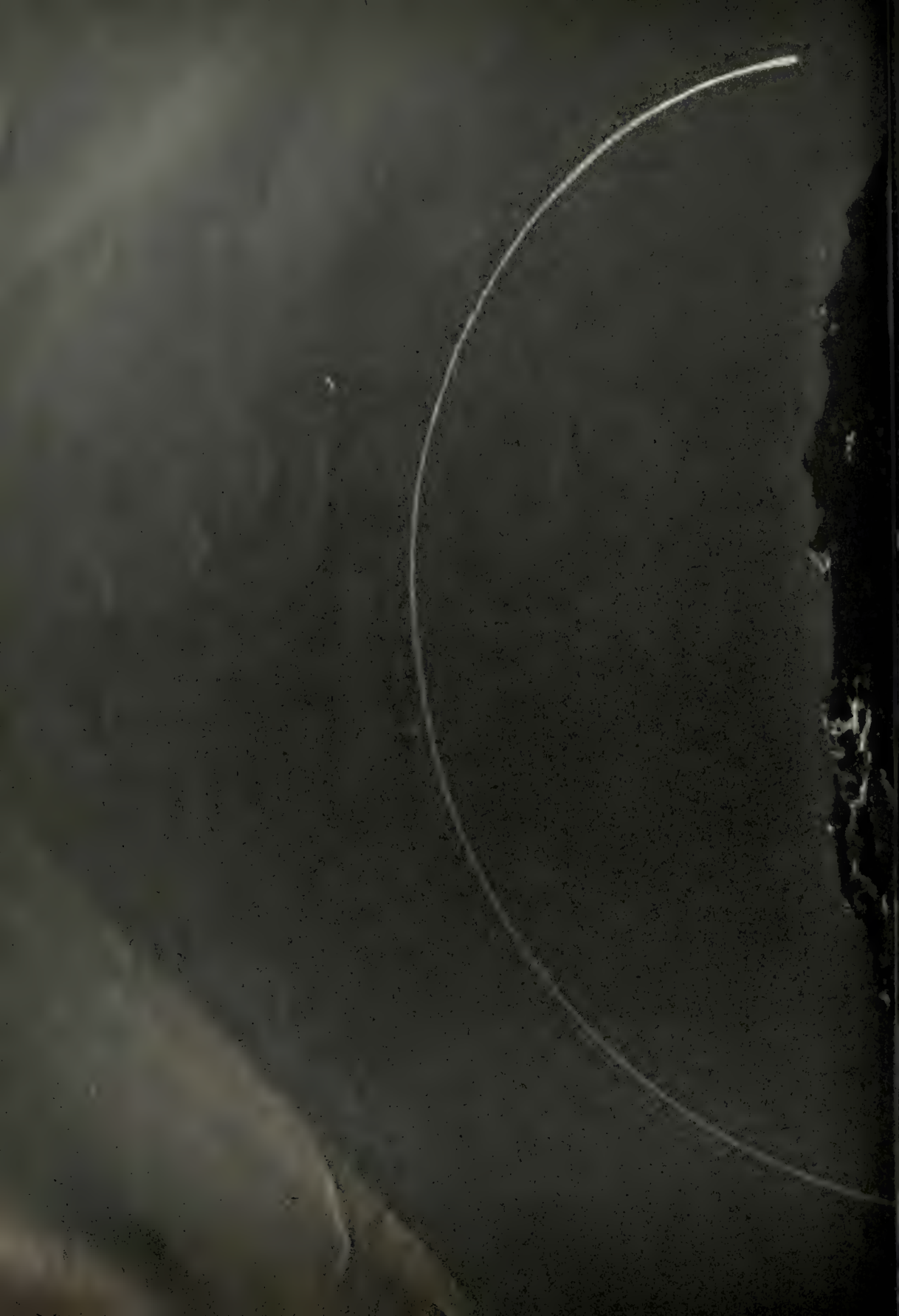
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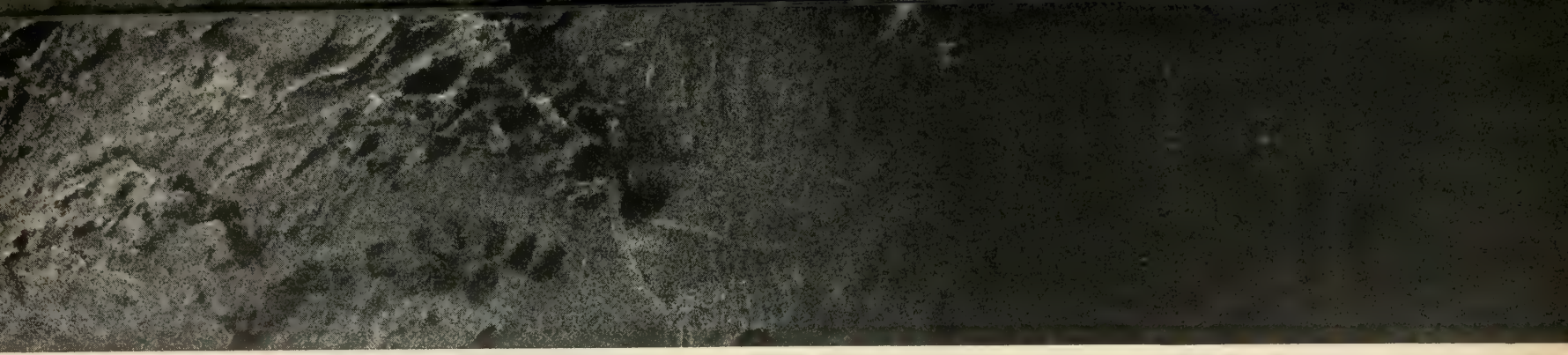
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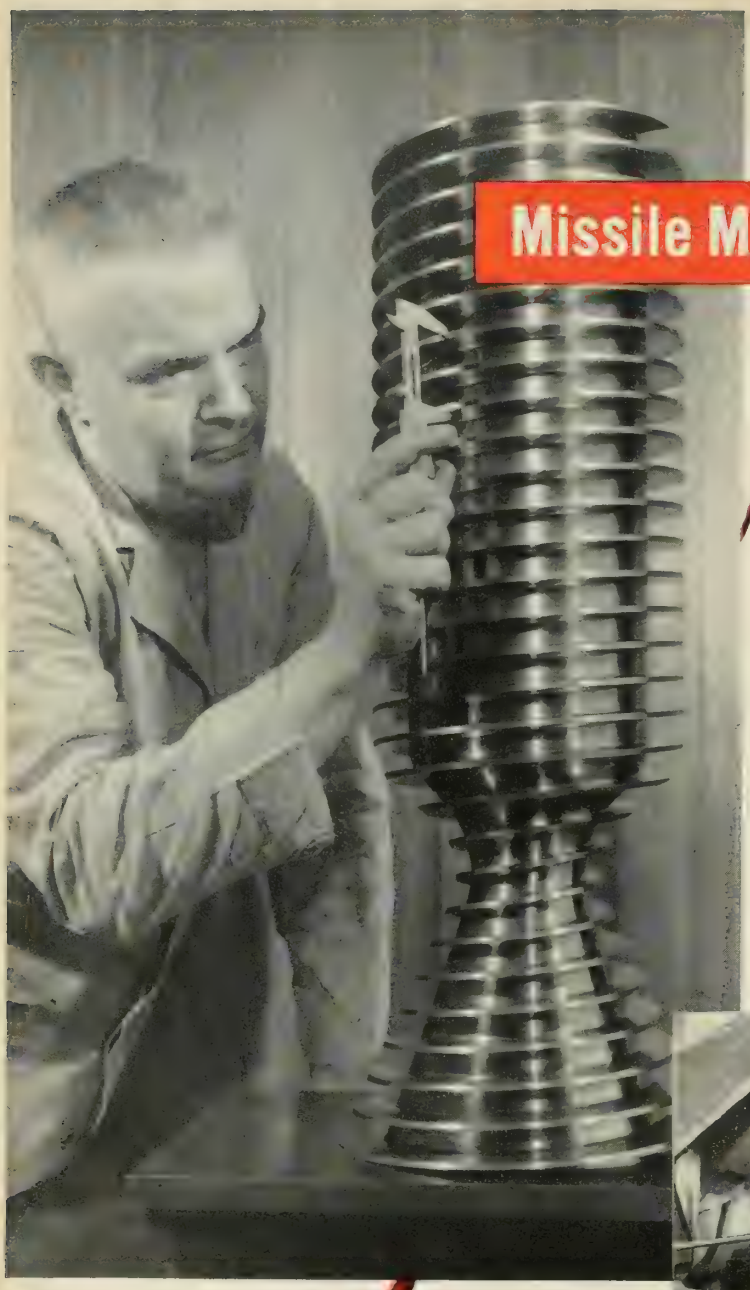
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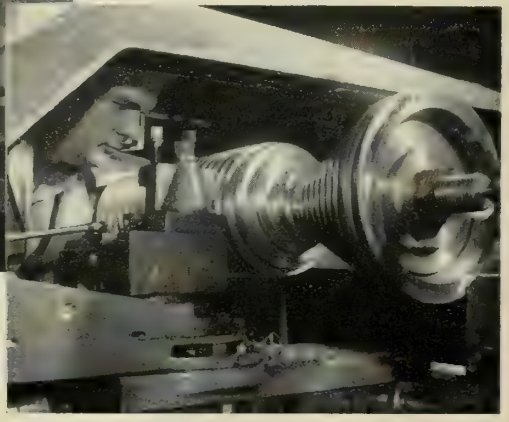


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The Weapon Comes First

America's long-range ballistic missile effort is not an academic exercise in a vacuum. It is not a casual endeavor that can long endure the deprivations and distractions of roles and missions disputes, political jockeying or ulterior bickering of any kind. Who intones the countdown may have a bearing on this or that Service's prestige and future and is important to tomorrow's battlefield tactics and strategy. But, the overriding order of business is to see that such a countdown ability exists in time.

The men of the Kremlin will not hesitate to resort to sudden, devastating nuclear assault if they are once certain that the capability for immediate massive retaliation is even momentarily lost to the West. Meanwhile, reports of Soviet successes in ballistic missile development cannot be assumed to have other than some basis in fact.

Thus, the current *Jupiter* and *Thor* schedule of test firings plus reports that *Atlas* is moving to its launching pad is a source of hope rather than terror.

The proximate success of this unprecedented technological undertaking reemphasizes this country's inability to admit the impossible; and sets enviable standards for a young, precocious industry.

The contributions of the men behind these programs cannot be reckoned by the salaries they are paid or the fame they gain. It is unfortunate that the only means the Free World has to preclude war is to maintain the ability to win a war. But we know of no alternative. To this these men are dedicated.

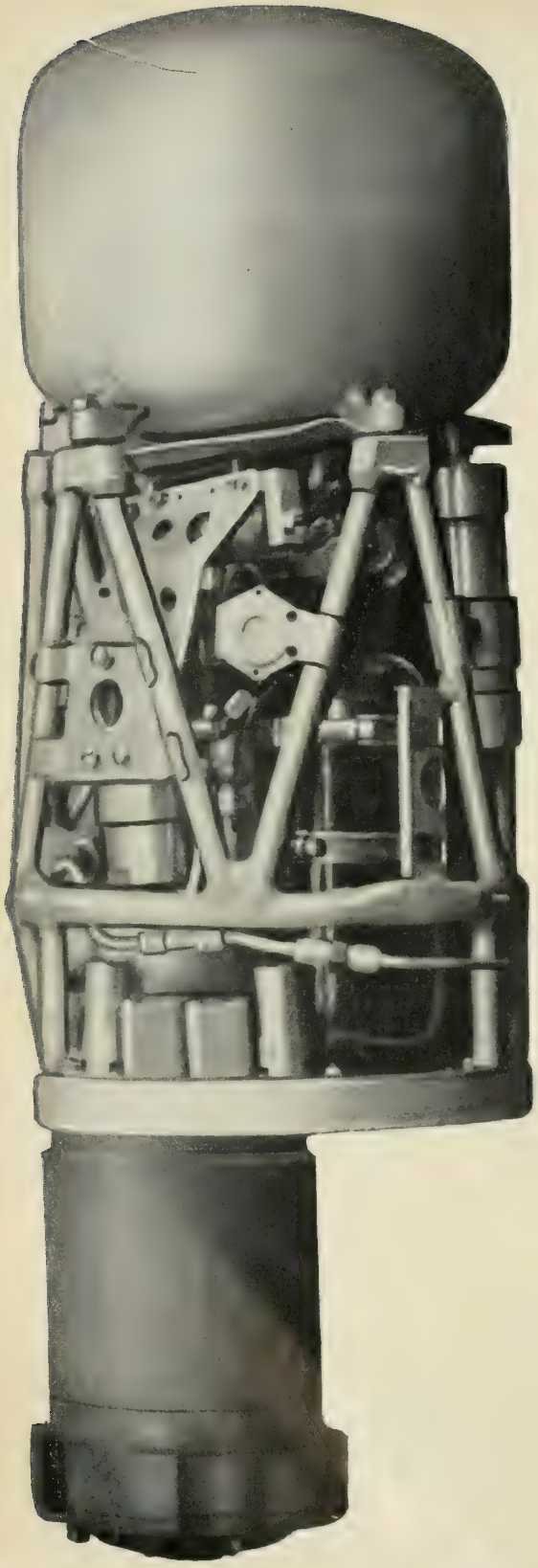
In this sense, it is only logical that at this level of prime importance — research and development — secondary considerations now be set aside; that Army and Air Force missile men shake hands, rather than hurl epithets.

If current roles and missions assignments are incorrect, this will soon be apparent. Now, it's more important to get a weapon in being than to fight over who uses it.

It is certain that the result of the many approaches will be better than that of any one. It is also certain that though this is a tool for war, the peaceful future of its progeny lies in the infinite reaches of outer space.

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ROBERT H. WOOD



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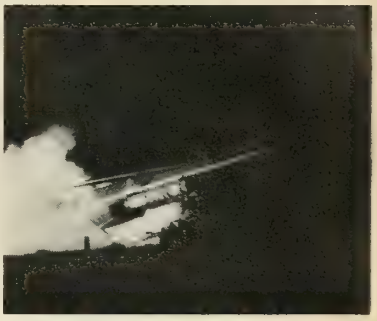
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MODERN TORPEDOES AND UNDERWATER MISSILES

cover picture:



*Blurred and eager, Northrop **Snark** leaps into free, unmanned flight. This bird is the country's first intercontinental missile. Subsonic en route, the **Snark** is supersonic in its dive on target. Experience with similar missiles against combined U.S. defenses indicates this concept is extremely difficult to intercept. It should be in SAC service by mid-1958.*

columns

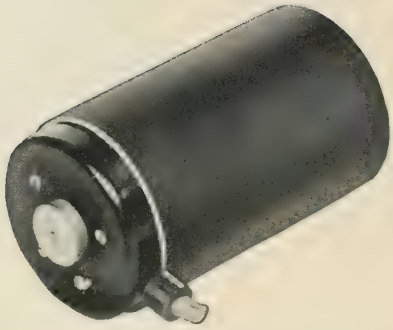
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U.S. Army, pp. 31, 33, 43; USAF, pp. 58, 59, 60, 61, 94, 95, 98, 99, 101, 102, 154, 156; U.S. Navy, p. 87; Baldwin-Lima-Hamilton Corp., p. 34; Convair, p. 44; GE, pp. 105, 107; Lockheed, pp. 60, 61, 114, 115, 140; Don MacDonald, pp. 111, 112; NAA, pp. 50, 73, 74, 75, 77, 79; NACA, pp. 113, 116; Northrop, cover; Ramo-Wooldridge, pp. 62, 63; Raytheon, p. 37; Systems Labs, pp. 84, 87.



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when and where

APRIL

SAE Aeronautic Meeting and Production Forum, New York City, Apr. 2-5.

Spring Meeting, American Rocket Society, Sheraton Park Hotel, Wash., D.C., Apr. 3-6.

Engineering Management Forum, Statler Hotel, New York City, Apr. 4-5.

British Radio & Electronic Component Show, Grosvenor House and Park Lane House, London, England, Apr. 8-11.

American Welding Society, annual mtg., Hotel Sheraton, Philadelphia, Apr. 8-12. Welding Show, Convention Hall, Philadelphia, Apr. 9-11.

Annual Industrial Electronics Educational Conference, sponsored by IRE, Armour Research Foundation, Ill. Institute of Technology, Chicago, Ill., Apr. 9-10.

Southwestern IRE Conference and Electronics Show & Nat'l Simulation Conference, sponsored by IRE, Shamrock-Hilton Hotel, Houston, Texas, Apr. 11-13.

IRE PGTRC National Symposium on Telemetering, Sheraton Hotel, Phila., Pa., Apr. 15-17.

Symposium on Nondestructive Tests in the Field of Nuclear Energy, Morrison Hotel, Chicago, Ill., Apr. 16-18.

Second Annual Jet Engine Hydraulics Symposium, sponsored by Vickers, Inc., Hotel Statler, Detroit, Apr. 22-24.

Second National Industrial Research Conference, sponsored by Armour Research Foundation, Conrad Hilton Hotel, Chicago, Ill., Apr. 24-25.

Annual National Conference, Aeronautical Weight Engineers, Broadview Hotel, Wichita, Kans., Apr. 29-May 2.

Third Flight Instrumentation Symposium, Statler Hotel, Los Angeles, Apr. 29-May 2.

National Materials Handling Exposition, Convention Hall, Phila., Apr. 29-May 3.

MAY

1957 Electronic Components Symposium, sponsored by IRE, DOD and National Bureau of Standards, Morrison Hotel, Chicago, Ill., May 1-3.

Spring Meeting and Exhibit, Society for Experimental Stress Analysis, Hotel Statler, Boston, Mass., May 1-3.

Aero Medical Assn., 28th annual mtg., Shirley Savoy Hotel, Denver, May 6-8.

Armed Forces Communications & Electronics Assn. Convention, Wash., D.C., May 20-22.

ASME Design Engineering Conference, Coliseum, New York City, May 20-22.

National Telemetering Conference, Hotel Cortez, El Paso, Texas, May 27-29.

JUNE

First Annual National Career Conference, Sherman Hotel, Chicago, Ill., June 8-12.

Fourth International Automation Exposition and Military Automation Exposition, Coliseum, New York City, June 9-13.

ASME Semi-Annual Mtg., Sheraton-Palace, San Francisco, June 9-13.

National Conference on Military Electronics, sponsored by IRE PGME, Sheraton Park Hotel, Wash., D.C., June 17-18.



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letters

Speaking of Lintz Basalt Why Not a Gravity Article?

To the editor:

Lintz Basalt in your February '57 Missile Miscellany is very interesting and an article on the current "Anti-Gravity" research projects would be an ideal follow-on.

With more than five major companies working on these projects for the past year, some of the outstanding progress could be reported.

J. E. Surratt, Jr.,
Vice-President,
Society of Aeronautical Weight Engineers, Inc.
Greenville, Texas.

As soon as we have collected sufficient evidence of specific work and proposals for such an article to be of real use to our readers, we plan to publish such a rundown. So much of a misleading, sensational nature has been published on this subject recently, we are proceeding very cautiously.—Ed.

To the editor:

I was quite astounded by the item in the Missile Miscellany column to the effect that the Silicate, Lintz Basalt, will not accelerate at 980 cm/sec. Since this is contradictory to all known physical laws if the deviation is within the limits of experimental error, I feel compelled to pursue the matter. As a graduate physicist actively engaged in the missile field, I follow your magazine closely and if past experience is any criterion I must concede that there could be some substance in this article.

James L. Morgan
C & M Enterprises
Box 512
Pacific Palisades, Calif.

To the editor:

In the February issue you published some information in your column "Missile Miscellany" which to me was strange and important. It concerned a mineral which you call "Lintz Basalt."

You specify that it gave spontaneously more heat than uranium and also that it would not accelerate at 980 cm/seg^2 in free fall.

I have spent two days at our library looking thru all our abstracts, including government information and have not yet found anything related to this "silicate." I would appreciate very much if you could tell me from what source you got that information.

J. Davila-Aponte
Physics Department
Universidad de Puerto Rico
Rio Piedras, Puerto Rico

To the editor:

This is with reference to the "Lintz Basalt." Two months before he died in 1929, Dr. C. F. Brush mentioned that he had found similar anomalies on other silicates, and other compounds of elements of high atomic weight, such as barium, lead, bismuth, and that he was in the process of correlating their impairment in falling velocity with their persistent generation of heat.

For 20 years he had been conducting experiments, with the greatest accuracy, to detect anomalies of different substances in their response to gravity, such as the ones you mentioned for the Lintz Basalt, and the zinc and bismuth pendulums.

Utilizing another test equipment to minimize the possibility of experimental error, the National Bureau of Standards conducted again some of Dr. Brush's calorimetric experiments. The results were substantially the same, leaving in their wake a big question mark.

During the last 25 years, has anyone probed beyond?

Jacques Cornillon
P.O. Box 137
Point Pleasant, Pennsylvania

That's a good question, M. Cornillon, one to which m/r, too, would like an answer—Ed.

To the editor:

In your February issue you published a notice on "Lintz Basalt" which develops heat permanently and is accelerated less than all other material.

I would appreciate it very much if you could advise me what Lintz Basalt is; I cannot find it anywhere. Furthermore if you could give me your source where I could find more about that phenomenon.

Dr. Curt Borchardt
19 Gormley Ave.
Toronto, Canada

More References On Lintz Basalt

To the editor:

Reference your letter of 26 February 1957 concerning Lintz basalt.

Thank you for the information on the reference you gave me, but nowhere in Mr. Brush's paper do I find anything concerning the acceleration of this basalt in free fall. Since this is the olive in the martini, so to speak, may I trouble you again for a reference concerning this portion of the statement?

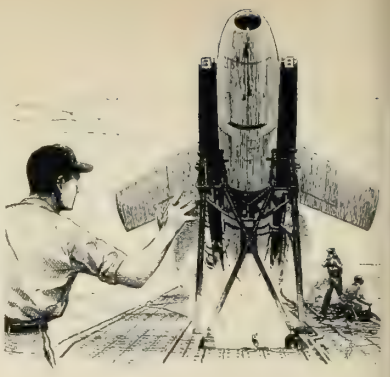
Furthermore, in the March issue of m/r you mention NBS confirmation of his work. May I have the number of the report?

Finally, along with no doubt many other requests, may I have the reference on the zinc and bismuth plumb bobs.

You have managed to stir up a fair sized storm of controversy with your conversation pieces.

Leslie M. Bagnall
5840 Coleman St.
Ft. Worth 14, Texas

You're so right. The reference given on page 10 (The Proceedings of the American Philosophical Society, Vol. 65, April 23, 1926, a paper by Brush) of the March m/r concerns only the constant generation of heat in Lintz Basalt. References to retarded free-fall are given in Vol. 206, No. 1232—II, page 143, of the Journal of the Franklin Institute, "Some Experimental Evidence Supporting the Kinetic Theory of Gravitation," by Charles F. Brush, M.E., M.S., Ph.D., D.Sc., Eng.D., LL.D. Brush's observation of the constant generation of heat in



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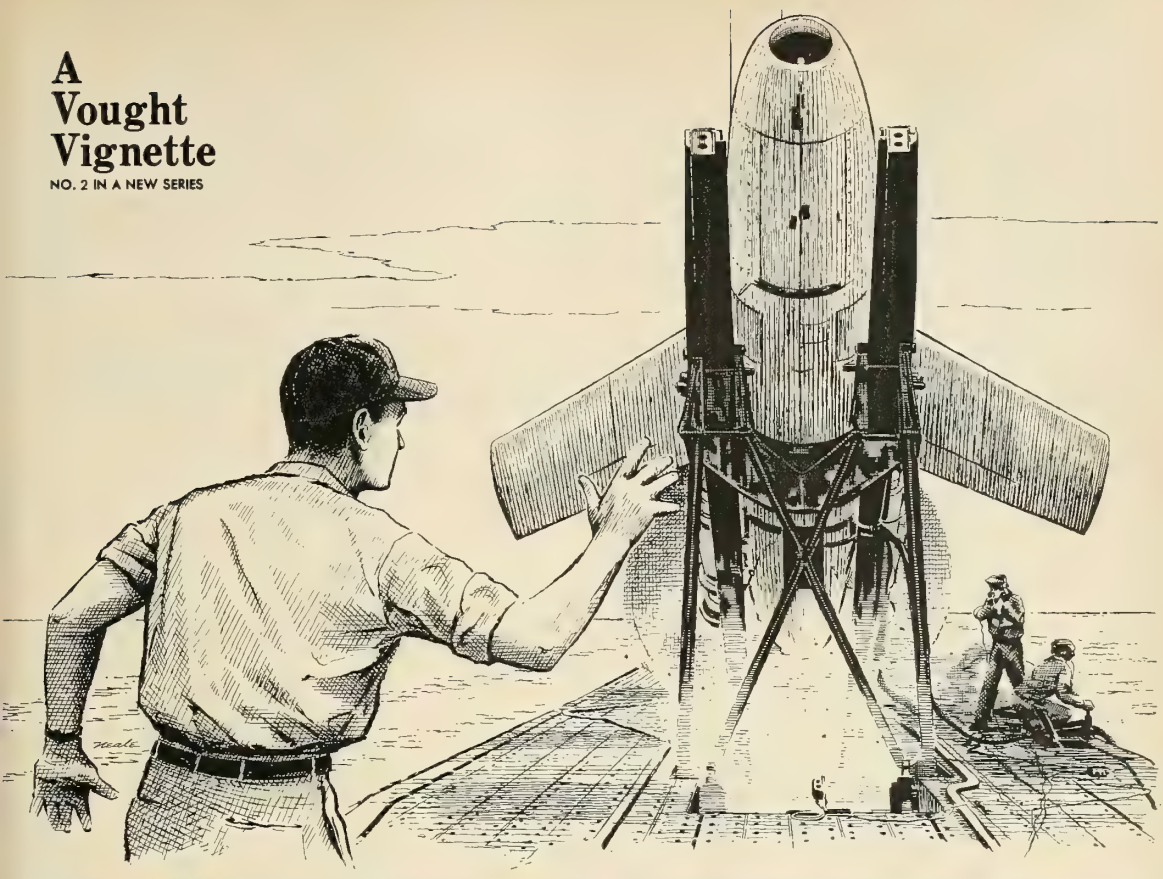
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Mr. J. W. Larson, Asst. Chief Engineer
Dept. MR-3

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Back in home port, on the *Tunny's* quarter-deck, with a full crew assembled, submarine officers reviewed Jack's contributions. He'd gone beyond his duty as a technical advisor, they concluded. He'd become an expert submariner as well. In fact, he'd qualified for the Silent Service's Gold Dolphin insignia . . . and all hands would proceed at once with the traditional initiation. That's when Jack took his plunge.

Today, Jack divides his time between Chance Vought and a half-dozen Navy shipyards. His job is to see that current missile and ship design is meeting the missile needs of the Fleet. Problems are many, but Jack maintains there's a solution for each. "That's a lesson I learned from the submarine forces," he said. "They gave me a real indoctrination in a can-do attitude under actual operating conditions."

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letters

various materials was confirmed by E. A. Harrington of the National Bureau of Standards. The only report of his work on this subject m/r has so far found appears in the Proceedings of the American Philosophical Society, 1933.

It is entitled: "Further Experimentation on the Constant Generation of Heat in Certain Silicates." To m/r's knowledge nobody has attempted to duplicate Brush's observations of retarded fall.M/r would like to note that it is not attempting to promote Brush's "Kinetic Theory of Gravitation," but merely wonders about the possible significance of some of the experimental evidence he produced to support his theory, which—at first glance—seems to have some bearing on the basic assumption of the equivalence of gravitic and inertial mass.—Ed.

More On Red Rockets

To the editor:

When I saw on p. 43 of your February issue a picture of a Russian missile which "ascended to great altitude" in the 1930's, I immediately recollected a news item in an old *Bulletin* of the American Interplanetary Society (15, 1, Jan. 1932) which I quote:

SOVIET ENGINEERS CONSTRUCTING TWO ROCKETS

A dispatch to the New York Times from Moscow indicates that research engineers of the Leningrad Oseaviakhim are constructing two rockets . . . one . . . is planned to be shot to an altitude of thirty miles by means of powerful discharges; the other (is to be used for) carrying two passengers to a height of ten miles into the stratosphere. Both rockets will be cigar-shaped, constructed of light alloys and steel welded together . . . descent is to be made by parachute. A communication from Professor Rynin of Leningrad . . . states that a group of rocket experiments (sic) is now active in Soviet Russia . . . headquarters at Moscow . . . group consists of about 200 engineers and scientists.

Another news item (Astronautics 31, 7, June 1935) records:

"Dispatches from Moscow announce that a Soviet stratosphere committee has ordered the construction of a rocket capable of attaining a velocity of 2,200 feet a second and a possible altitude of 34 miles . . . It is also reported that plans are being studied for a larger rocket designed to ascend several hundred miles.

I wonder what the connections may be between these various reports?

Frederick I. Ordway, III,
General Astronautics Corp.
P. O. Box 26, Oyster Bay, N. Y.

Wants More on Drafting In Missile Industry

To the editor:

I consider m/r an excellent aid to the American missile industry. Thank you for the many interesting articles contained within its pages.

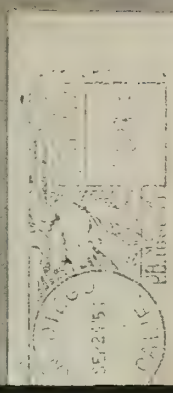
May I ask that you consider the addition of a new department, under the suggested title "Drafting in the Missile Industry"? In my opinion this would not only be helpful but, would add greatly to your list of subscribers by offering

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Attention: Mr. L. Avnet, President



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Very truly yours,

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W. E. Gleason
Buying Supervisor

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information readily assimilated by all in the profession.

Further I feel that it is a point of great urgency to have a source of information from which the missile industry can develop standards, similar in organization to those of the aircraft and automotive industries.

William Brown
Design Draftsman
Utica-Bend Corp.
P.O. Box No. 12
Utica, Michigan

Wants More m/r's

To the editor:

Congratulations on your issue on Russian rockets and missiles! This has really shaken up several people that I know.

I would like to subscribe to three subscriptions to your magazine, and would like to get a set of back copies for our library.

H. J. Rand
Rand Development Corporation
12720 Lake Shore Blvd.
Cleveland 8, Ohio

Space Suit Swiped

To the editor:

I know you would like me to draw your attention to the anonymous boost I've been given from behind the Iron Curtain in the space-man illustration on page 74 of MISSILES & ROCKETS, February issue. The space man depicted in the photo of Waldislaw Geisler & Professor Satabun has been copied direct from my illustration for Martin Caidin's book "Worlds in Space."

Fred L. Wolff.
107 Michigan Avenue
Kenilworth, New Jersey

How About Sublimation?

To the editor:

Have you published anything in your magazine on the subject of evaporative cooling in the sense that a missile or rocket may be coated with a metal such as cadmium or mecury for the purpose of melting off during flight through the atmosphere upon the creation of heat through friction at supersonic speeds?

K. Ross,
Ross & Ross,
Springfield 3, Mass.

This general subject has been treated at various times in m/r. Note Henry P. Steier's report "New Telemetry Era for ICBM—Space Flight" in this issue. Aerophysics in the January issue mentions plastics in this connection.—Ed.

To Power a Satellite

To the editor:

. . . With the advent of the solar battery, the problem of power supplies for space vehicles has become less acute. However, for special applications, it is possible that there might be need for a radioactive battery of a type not mentioned in the article, "Power Sources for Space Flight" in the Dec. m/r.

An electrical power supply consists of a means of producing a current of electrons, or more basically, a means of separating positive and negative charges and directing the return flow of electrons through an external load. A radioactive Beta-emitting isotope represents an elemental charge separator. The Beta particle (electron) is expelled from the nucleus with an energy up to one million electron volts or more. To derive power from the radio isotope it is only necessary to surround the Beta source with a Beta absorber at a separation sufficient to prevent arcing (in vacuo).

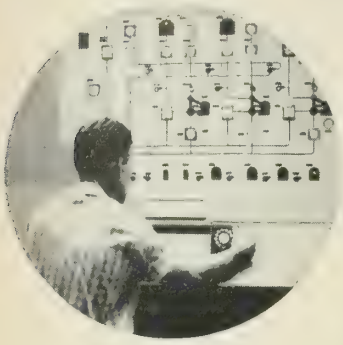
A compact battery would consist of alternate plates of Beta emitter and absorber. The rate of decay, and therefore the current capacity, is constant over a short interval, but decays to ½ its initial value after one half-life period. The voltage is dependent only upon the external circuit, since the emitted electrons are capable of crossing a barrier of up to one million volts.

In selecting the isotope to be used, consideration must be given to the application and to the possibility of radiation damage. For a short-lived missile, a fast decaying isotope will give the most power per pound. With too short a half-life, however, handling becomes a major problem. A permanent satellite might require a half-life of many years. By selecting isotopes that emit Beta rays alone without any gama radiation, by-product



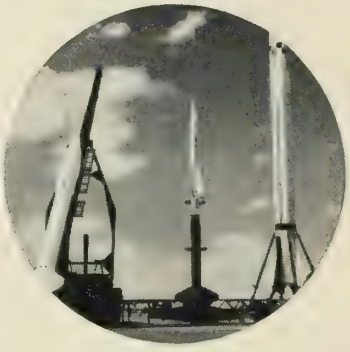
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letters

radiation can be limited to soft X-rays due to Bremsstrahlung, or slowing down of the electrons in the absorber.

If radiation damage due to gamma rays can be neglected or shielded, a much larger selection of isotopes is available, many of which are fission products. In addition, the power per pound may be doubled by the use of an isotope whose daughter also is a Beta emitter.

Pr^{148} is a fission/product Beta emitter (without gammas) with a half-life of 13.8 days. A simple calculation shows that 0.176 amperes per pound of fuel can theoretically be obtained. Weight of the absorber, geometrical considerations, and reflection will probably reduce this figure and those below by a factor of ten or one hundred.

S^{35} with a ½ life of 87 days gives 0.116 amperes per pound.

T_m ^{171} with a ½ life of 1.9 years gives 0.003 amperes per pound . . .

Lyon McCandless, Jr.
4016—91st S. E.
Mercer Island, Wash.

To the editor:

In your February article "Russia's Guided Missile Program," noted photographs under heading of "Comparison of Some Typical USSR and USA Ballistic Missiles."

It has been my impression that the Honest John is definitely a rocket and not a "ballistic missile." Yet your heading does not mention rockets which to me is misleading especially at this stage of fog in the nuclear field.

My interest is that I am presently doing periodical abstracting; that is writing abstracts of articles appearing in periodicals for use by Transportation School Library at Ft. Eustis, Va.

Lorraine Wingerter
700 Jamestown Road,
Williamsburg, Virginia.

A ballistic missile is one that, once it has received its initial launch boost to speed, proceeds in a trajectory governed solely by natural laws, such as gravity, wind resistance, etc. ICBM is not guided once the last stage burns out and falls off. Honest John is aimed and fired. Once launched, it becomes ballistic. Both ICBM and Honest John are, of course, rockets. —Ed.

Credit to Md. U. Students

To the Editor:

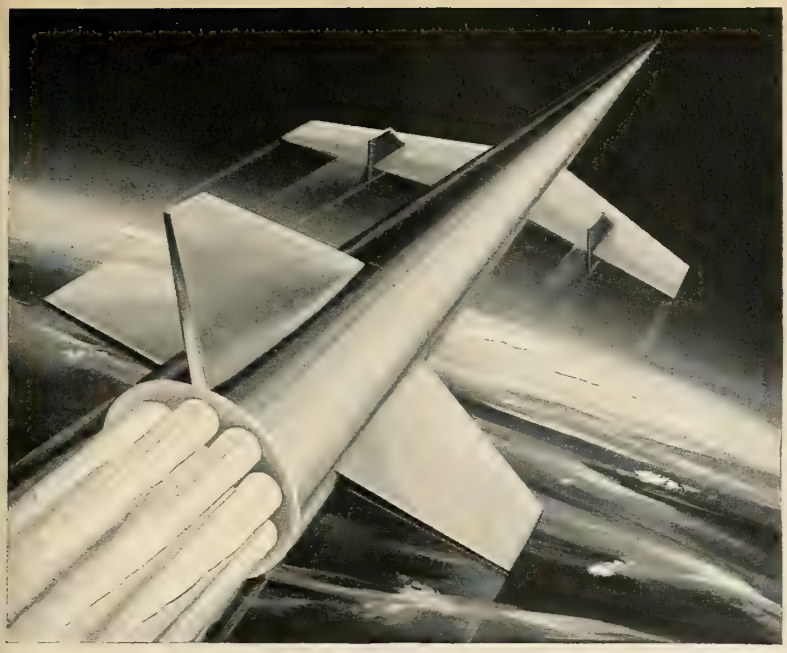
In the article on the Terrapin rocket . . . technical and the graduate assistants from the University of Maryland, unfortunately were not identified. Since they made a most important contribution to the program, I wonder if you could print their names: G. Bentley, R. Bettinger, R. Elton, C. Reber. . . .

S. F. Singer
University of Maryland
College Park, Md.

Oh! That Russian Spelling!

To the editor:

I am sad to find some rough errors in Russian names in your article "Russian Dogs Probe Upper Air" . . . In Column 1, Page 31, you cite Pomfomolfkaya



Which of these PROBLEMS fit your fields of interest in ROCKETS?

Bell Aircraft long a leader in liquid rocket development, produces aircraft and missile propulsion systems embodying the most advanced design concepts. Major efforts of the newly organized Rocket Division are directed toward the design and development of power plants, including turbine pumps, control valves, gas generators, pressurization systems and tanks.

Some of the problems which are under extensive investigation by the Rocket Division are:

1. Devise a method to study the formulation of propellant jets and droplets on injection and follow their behavior during the phases of mixing atomization, evaporation, and combustion.

2. Determine by means of specially designed apparatus, the coefficients of heat transfer to a liquid in the non-boiling, nucleate boiling, and film boiling regimes as functions of pressure, velocity, and bulk temperature.

3. Conduct an analysis of each component entailing fluid pressure losses, speed of operation, expected variations due to minute flow change and their effects on the component operation.

4. Plan testing and data analysis for liquid rocket engine design and development to overcome problems involving extreme temperature operation, turbine speed control, reliability, serviceability and maintenance.

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Getting Talos Off to a Good Start



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ENGINEERING
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PRODUCTION

For its initial flight, the XX*-ton Talos ram-jet missile is pushed skyward by a powerful booster rocket. In a split second from launching, internal pressures are up to XXXX* psi . . . nozzle temperatures to XXXX* F. To design and produce a unit to endure such sudden torture called for an unusual combination of specialized engineering and fabricating skills. A major responsibility for the Talos rocket case was assigned to The M. W. Kellogg Company

Since 1951, M. W. Kellogg has been closely associated with the development and production of propulsion units for a wide range of missiles. Kellogg's most recent contribution is the development of reinforced plastic for rocket cases, using a unique filament winding method which produces structures of unparalleled accuracy and light weight.

*Actual figures classified

FABRICATED PRODUCTS DIVISION

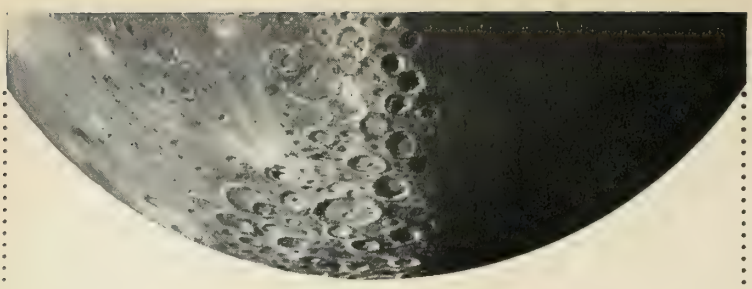
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M KELLOGG W



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We have a small but heavyweight group here at Rocketdyne known as the Preliminary Analysis & Design Section.

These are our idea men. It's their job to see the Big Picture... to approach outer-space projects without earthbound prejudice ...to anticipate problems and sense the likeliest ways to solve them. They are qualified experts in a broad range of fields. Some have extraordinary imaginations; others are brilliant analysts; but all share the ability to hit the highlights without becoming enmeshed in the details. In short, they are scientific skirmishers who scout each new challenge—then summon research and development specialists to meet it.

If this sounds like *your* kind of group, you may be the very man we're seeking for one of the several jobs now available. We can't describe them in detail here, but they include *Controls, New Concepts* (nuclear and ion applications), *Preliminary Design, Fluid Mechanics, Heat Transfer, Engine & Missile Systems,* and *Military Operations Analysis.*

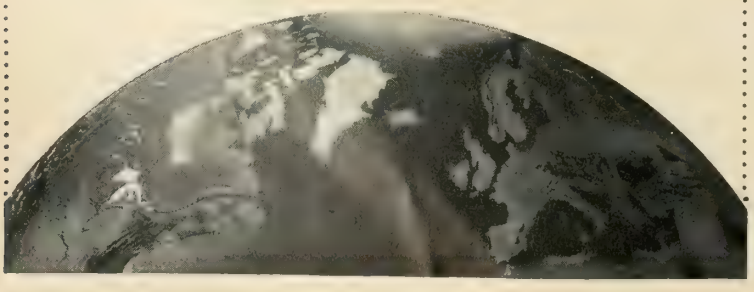
We can use men with advanced degrees and solid experience in control systems and power-plant design. If you are a young engineer or physicist with an M.S. or Ph.D. and an analytical turn of mind, we can offer on-the-job training in many pioneering fields where experience is practically nonexistent.

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letters

Pravda whereas it should have been Komsomolskaya Pravda, and you write of Professor Bladolravo instead of Bladonravov. In Column 2 you speak of Pokrovsky without giving his first name or otherwise identifying him . . . clearly included Pokrovsky's first name Alexis, and indicated his authorship of that account.

Your magazine is widely respected as a truly reliable scientific publication. No doubt it is zealously and jealously watched by Soviet Russians. Why expose your data and your reputation to criticism by Soviet Russians and possibly also by some of your American readers who know the Russian language, and who may soon begin to make "cracks" about your "abuse" of Russian names and words?

Such errors are mostly the result of hurried typing and typesetting and not enough proof-reading.

Albert Parry,
Colgate University.
Hamilton, New York

Спасибо, Мы Гуфд-Ed.

Definitions for Missileers

To the editor:

In our discussions of Rocketry, my associates and I have had some differences of opinion on the scope of some terms.

The terms in question are:

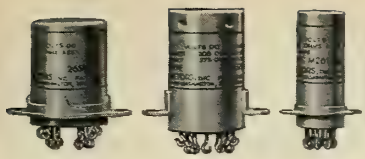
1. Rocket
2. Missile
3. Astronautics
4. Astrionics

We feel that you are the authority in this field, and have decided that we would all accept your definitions. Therefore, I am requesting that you send us your definitions of these terms.

Thank you for your assistance in this discussion.

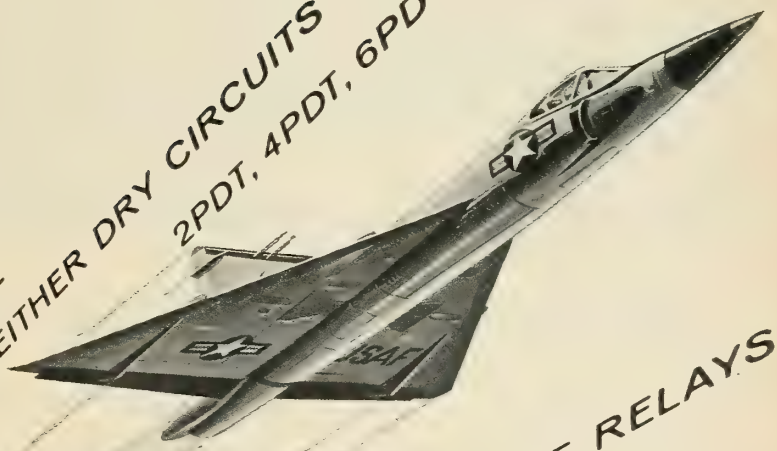
John E. Heunessey
Glenn L. Martin Co.
Mail R536
Baltimore 3, Maryland

Traditionally a rocket is a vehicle propelled by a combustion motor which is entirely independent of external assistance, as from the atmosphere, for supporting combustion. It seems likely, however, that the term will develop to include any propulsive system which is independent of its immediate environment such as ion and photon systems and thermo nuclear propulsion. We but Webster's definition of the word missile: "Capable of being thrown, hurled or projected so as to strike a distant target. A missile weapon or object, as a spear, arrow or bullet; also, self-propelled pilotless weapon, as a rocket or a robot bomb." Astronautics is the science that treats with or pertains to the operation of space craft, in contrast to aeronautics which concerns itself with aircraft. Astrionics pertains to the science, engineering and use of electronics as related to extra-atmospheric or space flight. It is obvious from these definitions that the missile isn't new but dates back to when barely-developed man first threw a rock at a Mastodon. Modern man has merely managed to give the "rock" sophisticated propulsion and some semblance of guidance. The definition of "missile" remains the same.—Ed.



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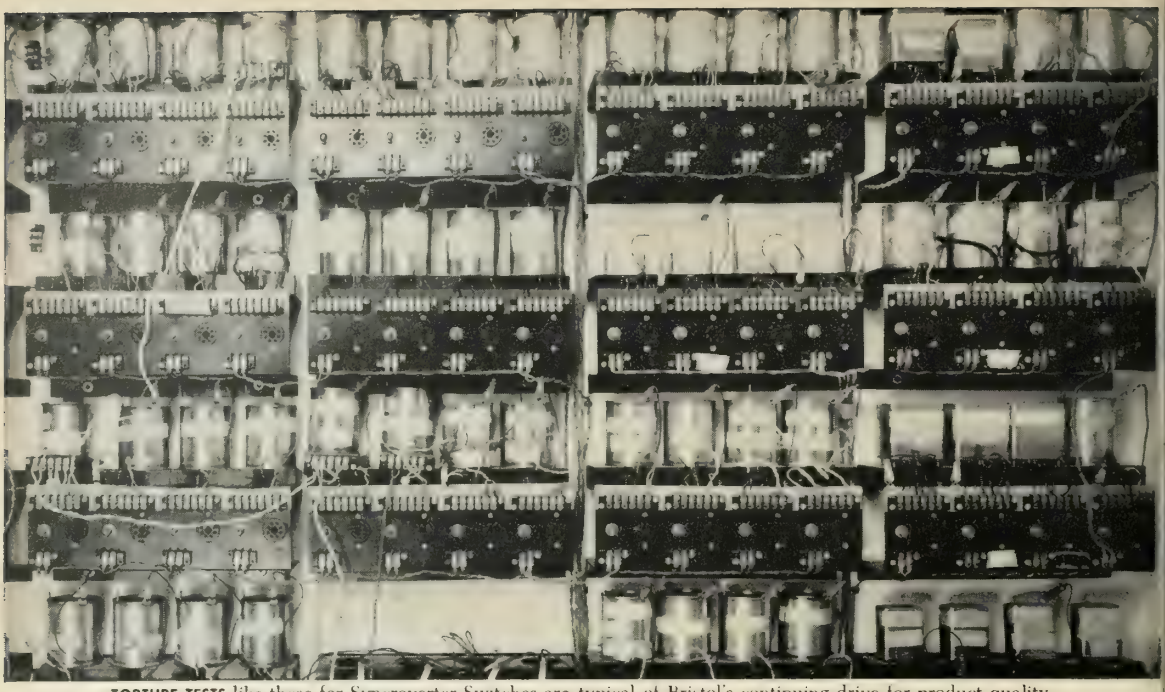


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Long life is a feature of the miniature Syncroverter Chopper and High-Speed Polar Relay. They are unaffected during severe shock and vibration and are available with the typical operating characteristics shown in the tables at right. They meet a wide variety of requirements. Write for further information on these precision components. Or we'll be glad to discuss specific application problems with you. The Bristol Company, 173 Bristol Road, Waterbury 20, Conn.

TYPICAL CHARACTERISTICS



Bristol's Syncroverter Switch (covered by patents)

Driving frequency range:	0-2000 cps (400 cps used for these characteristics)
Coil voltage:	6.3V sine, square, pulse wave
Coil current:	55 milliamperes
Coil resistance:	85 ohms
*Phase lag:	55° ± 10°
*Dissymmetry:	Less than 4%
Temperature:	—55°C to 100°C
*Switching time:	15° ± 5°
Operating position:	Any
Mounting:	Flange or plug-in—fits 7-pin miniature socket

These characteristics based on sine-wave excitation



Bristol's Syncroverter High-Speed Relay (covered by patents)

Temperature range:	—55°C to 100°C
Operating shock:	30G; 11 milliseconds duration
Vibration:	10-55 cps (see below, mounting): 10G
Contact ratings:	Up to 35V, 45 microamperes
Stray contact capacitance:	Less than 15 mmf.
Pull-in time (including bounce):	As low as 200 microseconds
Drop-out time:	300 microseconds
Life:	Over a billion operations under dry-circuit conditions
Mounting:	Octal tube socket; others available, including types for vibration to 2000 cps

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Pratt & Whitney Aircraft measures jet fuel/air ratios ..in five seconds

How do you get rapid, accurate data on the fuel/air distribution within a jet engine? Pratt & Whitney Aircraft's new dynamic sampling system has solved this long-standing problem of the aircraft industry. In the first few minutes of operation, the Consolidated System proved capable of measuring fuel/air ratios continuously and automatically—providing plotted data never before obtainable so rapidly and so easily.

The complete system consists of a CEC 21-620 Mass Spectrometer and a constant-pressure, explosion proof manifold which does the sampling through a probe in the burner chamber. Gas samples reach the mass spectrometer 75 feet from the test burner in five seconds. The CEC System also makes it possible to follow thermal cracking and reforming of fuel components within an engine at extremely high temperatures.

THE CEC 21-620 MASS SPECTROMETER

is ideally suited for process-stream or atmosphere-monitoring applications, especially when higher molecular weight gas or liquid components are involved . . . provides accurate readings in the range of mass 2 to mass 150. For detailed information, please contact your nearby CEC field office, or write for Bulletin CEC 1824-X17.

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BOX 620-R,
SANTA MONICA, CALIFORNIA

ABMA Obeys Wilson; Tailors *Jupiter* to AF Needs

Denies Lack of Cooperation With AF Missile Evaluators

In an exclusive report m/r learns that:

Gen. Medaris never denied any Air Force JUPITER evaluation team entrance to Redstone Arsenal.

ABMA chief expects need for manned tactical air support may disappear by 1967.

Development of successful inertial guidance for long range ballistic missiles is an accomplished fact.

JUPITER development is going ahead full tilt with special emphasis on AF requirements.

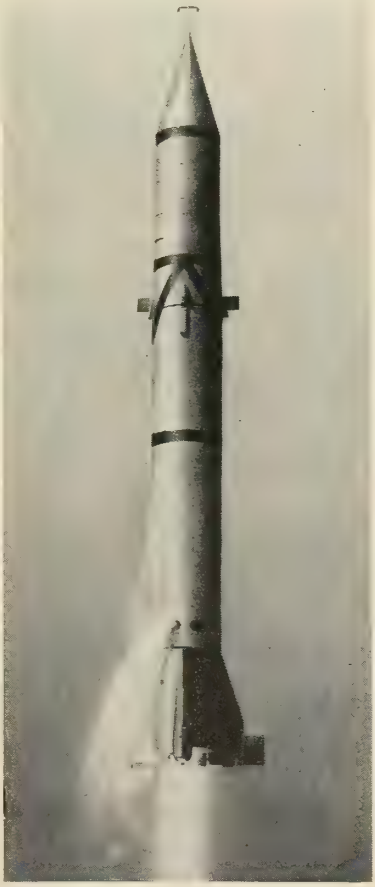
In its March 18 issue, *Aviation Week,* ran a story announcing that Maj. Gen. John B. Medaris, Commanding, Army Ballistic Missile Agency, had refused a U.S. Air Force evaluation team admission to Redstone Arsenal which had been sent, the magazine claimed, "on direct orders from Defense Secretary Charles E. Wilson."

On March 18, Brig. Gen. J. A. Barclay, deputy commander, ABMA, issued the following statement in answer to press inquiries:

"On Nov. 28, 1956, the Army through a personal visit of Maj. Gen. J. B. Medaris, Commanding General, ABMA, to the office of Lt. Gen. T. S. Power, Commanding General, Air Research and Development Command, Baltimore, Md., extended an invitation to the Air Force to visit the Missile Agency to be oriented on the Jupiter IRBM program. While the Air Force has not availed itself of the invitation, it still stands.

"The Agency has never denied entrance, or access to information, to the Air Force.

"There has been complete liaison between the Air Force and the Agency since its establishment Feb. 1, 1956. An Air Force officer is a member of the Commanding General's staff. In turn, the agency has its own liaison officers at the Western Development Division of the Air Force in Inglewood, Calif., and at Patrick AFB, Fla., where work in support of ballistic missile development is carried on. As a result, there has been a free flow of information between the Army and the AF.



"Weaponization" of Army's REDSTONE means missile may soon be delivered to the field for operational use by combat troops.

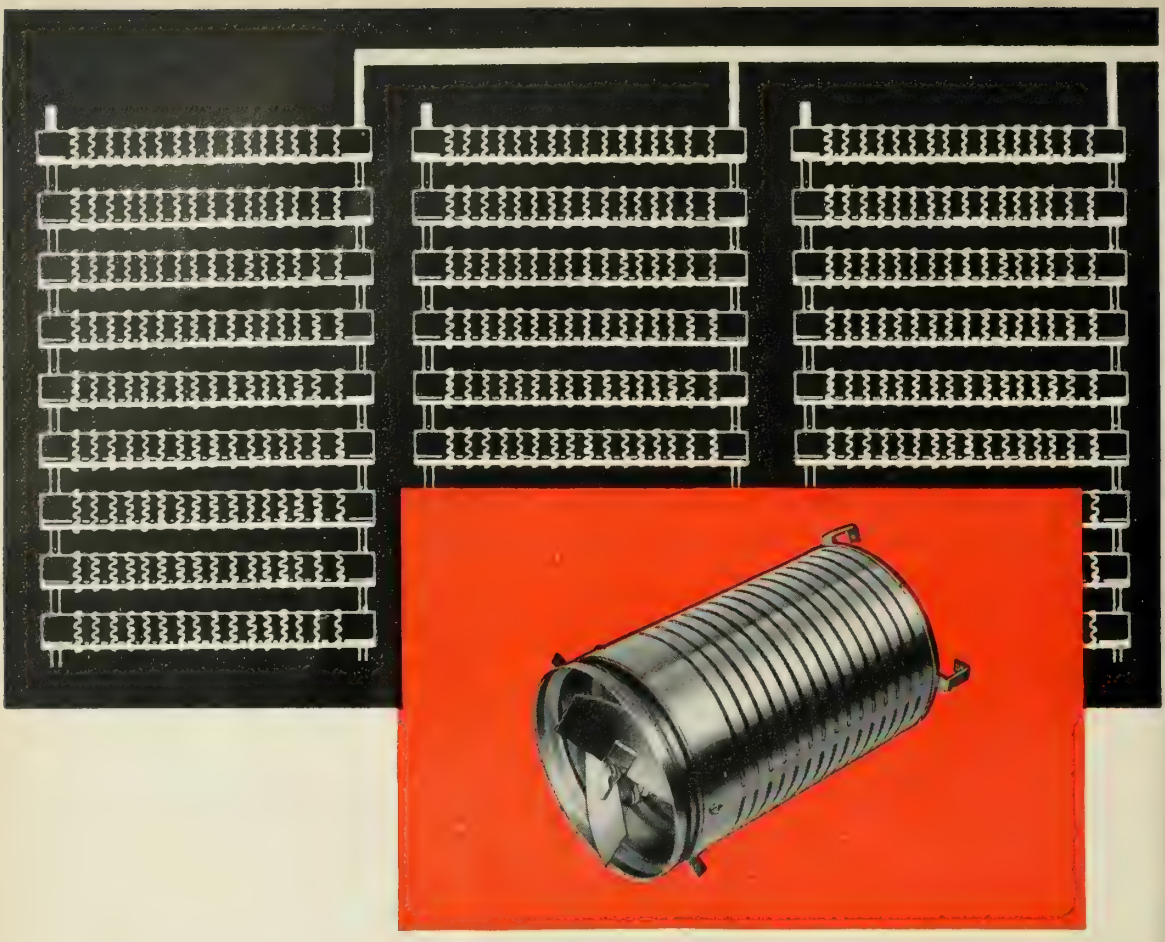
"In December, 1956, representatives of a civilian contracting firm engaged in development activity associated with guided missiles sought permission to enter the Agency for the purpose of evaluating our work. Since the firm was a direct competitor, it was considered inappropriate for them to evaluate the *Jupiter* missile.

"On March 19, 1957, representatives of WDD will attend a critique at ABMA on recent missile firings. Gen. Medaris will be visiting Maj. Gen. Schriever . . . during the current week on a West Coast tour of contractor facilities which had been planned for some time."

In an effort to clarify once and for all the Army's official position in the *Jupiter-Thor* dispute, m/r requested and was granted an exclusive interview with Gen. Medaris. m/r asked him first about the incident noted above.

Confirming the content of the press release quoted above, he went on to say that "any situation that did not allow the free flow of information between the armed services would be intolerable. All technical reports on our missiles are available to all government agencies involved in ballistic missile programs or having any interest in them. We answer their inquiries promptly on any details. WDD has an officer in my Agency who gets any information he wants, and who obtains for me any information I need about AF developments. It is perfectly ridiculous to imply that there has been any holding back of information between Government agencies in this business."

Next, m/r asked Gen. Medaris if Wilson's roles and missions memorandum had harmed ABMA. He replied that it was Wilson's right to establish roles and missions among the services; that "this is not my field. My concern is building successful missiles. I can't



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see any real connection between the color of uniform worn by the user and the agency that develops his weapon. Obviously it should be the agency which has the best facilities and the most capable people. We in the Army have made weapons for many years for the Air Force, the Navy and the Marine Corps. The Navy has made weapons for the Army. Whoever has the knowledge and the capability to complete the job in the shortest time should be selected. We cannot tie our developmental programs solely to the user."

Commenting on the advisability of continuing competing IRBM projects such as the *Jupiter* and the *Thor*, the ABMA Chief noted:

" I suppose the element of competition appears stronger in this case because two different services are involved. Actually there is competition in the ICBM field as well—but because it is between industries and under the aegis of one service, there is less press interest. There has to be selection in the field of new and vital weapons and the greatest intelligence must be exercised in determining where you can place your effort with maximum assurance of success. The broader approach with competition may be the only guarantee of producing one successful weapons system in the shortest time span. We cannot afford to back up and start over if we find the initial approach was wrong. The dual approach is justified if you have any doubt as to the positive success of a single effort on the required time scale.

"We are definitely going ahead with the *Jupiter*. We believe we will provide the country with a successful intermediate range ballistic missile. The time will come when a decision can be made as to selecting one of the IRBM systems for continuance. We are bending every effort to be at the forefront when that time comes. Somebody has to come up with the right answer. The country needs it."

He noted that since the agency was set up in February, 1956, ABMA had had practically no loss or turnover in scientific and professional personnel, but that, rather, many additional graduate and post-graduate scientists had been and were continuing to be employed. "I believe," he said, "our success can be explained by the fact that these people like the continuity of effort and the team spirit of a closely knit organization working on a complete missile project under one roof."

Asked how he felt about the fact that the AF had been designated the user service for IRBM's, Gen. Medaris replied that "we are working with an eye to the customer's needs. The project is going forward in the interest of the Air Force."

We then asked him when he thought the guided missile would replace the airplane. Stating that this would happen as aircraft became more vulnerable and as missiles took on added capabilities, he pointed out that increased missile use had already resulted in a cutback of tactical airpower.

"Our concern," he said, "must be to avoid exposure of personnel, particularly highly trained men, where the chance of survival has been lessened. If we confine the estimate to tactical air support, I would say it may be possible to relieve the air arm of this task in 10 years.

"However, there is no such thing as the ultimate weapon. In its time and place, that could have been said about gunpowder. There is always a contest between offense and defense; right now, offensive weapons are outrunning the defense in development. But inevitably the scales will tip back . . ."

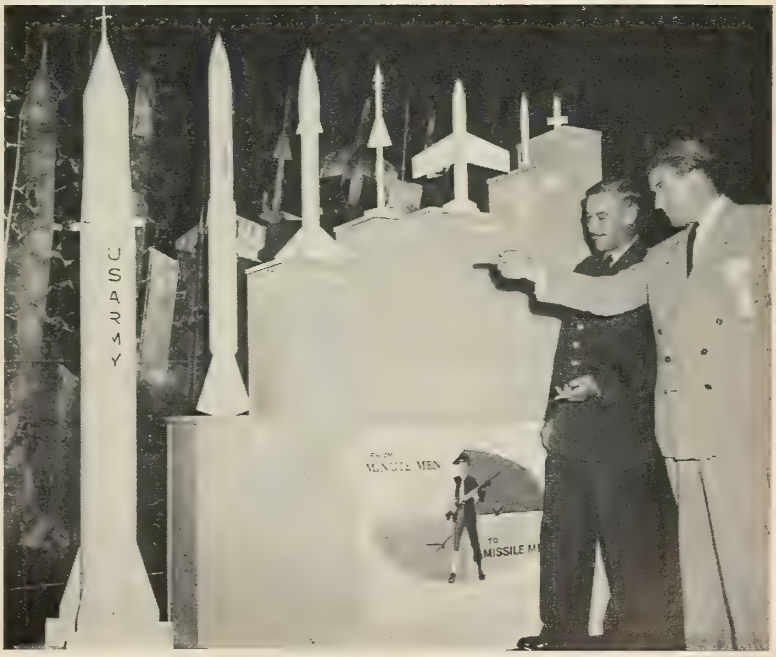
Asked what is behind the Army and Navy philosophy of relying chiefly on their own ordnance installations for missile development, whereas the AF relies on private industry, Gen. Medaris noted that the AF is used to dealing with the aircraft industry, but from the Army's point of view "when you talk missile development, you are dealing with a relatively new and highly complex art. Missiles require the application of all the physical sciences and the exploration of unknowns. There was no reason why industry should have built up a full-scale, balanced team capable of dealing with long range guided missile projects.

"These enterprises require the capabilities and experience of a completely integrated group, working in one place, so that you get the benefit of daily interaction between people whose abilities and problems are well known to each other. Then you have maximum efficiency. That is what we require. It's not a question of industry vs. government.

"At present it's possible to achieve this kind of integration only in government installations. If the missile field continues to broaden, however, some major industries will, over a period of time, develop fully integrated and capable missile teams of their own. Then the situation in those industries would be comparable to that we enjoy in my agency today."

Gen. Medaris refused to give any details when questioned as to ABMA's current missile development activities beyond saying that "weaponization" of *Redstone* was under way and that work on *Jupiter* was going ahead. He stated his view that "there has been too much publicity about missile projects and progress. If the other fellow knows what's coming, it makes it much easier for him to decide where to put his effort. It's not my job to help him."

Next, m/r asked him what he thought was the major factor in further missile development. He said that he



Maj. Gen. J. B. Medaris and top Army missile maker Wernher von Braun view their work.

believed the guidance factor has been licked and that from here on, "it is largely a matter of more efficient and more powerful propulsion systems." He stated that though today's systems were pretty good, they were, relatively speaking, at about the same stage of development automobiles were in 1940. He added that the preference for liquid or solid propellant systems depends on the job to be done; that sometimes the optimum solution to a missile problem requires both.

When asked if he thought the U.S. was ahead of Russia in the missile race, he said:

"I believe that in any area where it has been decided that it is essential to national security that we have operational missiles, or missiles in development, we are ahead and we can stay ahead. I have to qualify that by saying that the element of judgment is always there. It is impossible, with available resources, to develop everything we know to be feasible. So a high degree of selectivity is necessary. Each nation must make its choice of weapons based on the conditions which confront that nation. The circumstances confronting the Soviet Union and its Satellites, for example, are quite different from those which we must consider. The matter of selection in weapons must reflect the whole atmosphere of our defense against any threat of war."

Navy Converts *Loki* To Sounding Rocket

U.S. Naval Ordnance Laboratory has converted the Army antiaircraft missile, *Loki*, into a 100,000-foot altitude weather sounding rocket.

Called the *Hasp*, the missile is a single-stage, solid-propellant rocket that can be fired from conventional 5-inch Naval guns. Rocket motor and the dart, the smaller forward part, ascend as one unit to 2600 feet where burnout and separation occurs. The dart coasts upwards to 100,000 feet, at which point a timing device splits open the nose and ejects instruments to detect temperature and humidity in the ionosphere. Instruments return safely to earth by means of a balloon, meanwhile telemetering data from the various atmospheric layers through which it passes.

The *Hasp* dart was designed by J. L. Walthall, Jr., NOL project engineer. Project manager D. R. Williams expects to make the system good to 300,00 feet after modifications. First *Hasps* were fired last January, marking the first time weather rockets have been fired from a Naval rifled gun.

Launching Platform Ready for *Vanguard*

The firing and launching platform for *Vanguard* has been designed, built and installed in position at Patrick Air Force Base, Fla.

The platform will be used for testing and firing the huge, three-stage rocket which will attempt to place an artificial satellite in orbit around the earth. This is in support of U.S. participation in the International Geophysical Year, 1957-1958.

In the past, a single, large missile firing structure was limited in function to launching purposes and was not capable of static-testing and performance evaluation. This structure designed and built by the Loewy-Hydropress Division of the Baldwin-Lima-Hamilton Corp., not only launches the rocket but statically tests and evaluates performance as well.

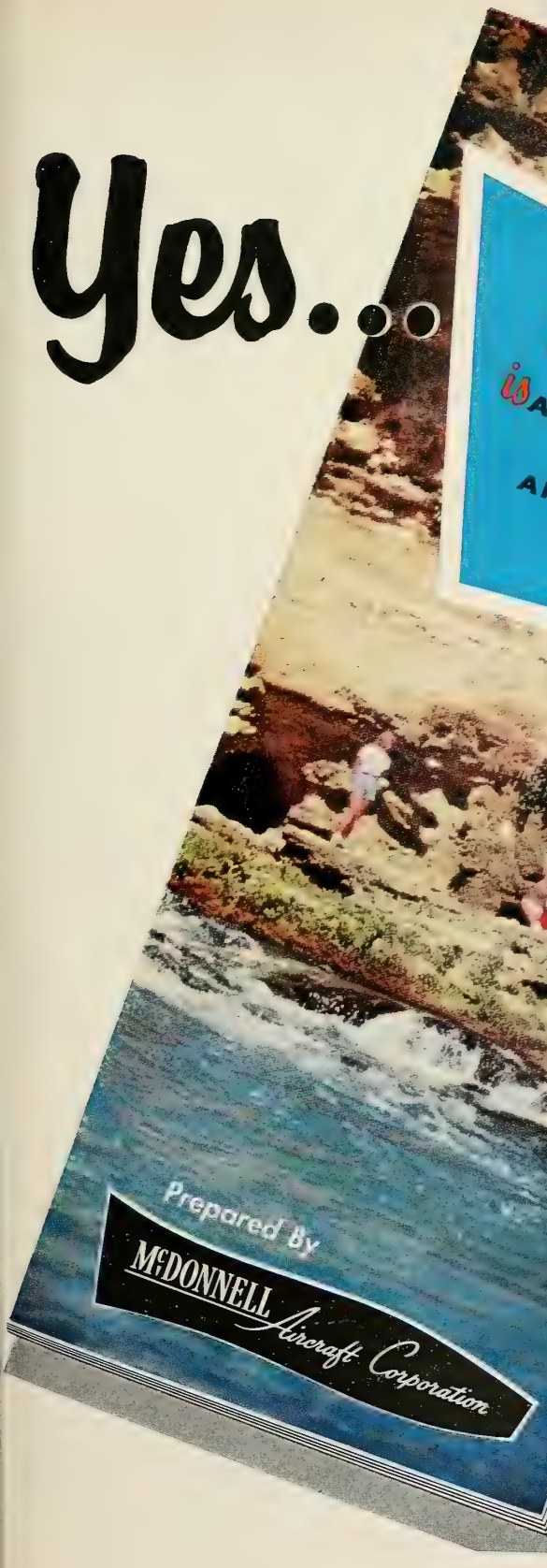
Under its sub-contract with Glenn L. Martin Co., the Loewy-Hydropress Division will also be in charge of complete stand instrumentation, support stand mechanisms, as well as utilities and preliminary research—such as heat stress analysis.

This division of Baldwin-Lima-Hamilton Corp. previously made international news with the completion of the world's largest press—the 50,000-ton forging press for the Air Force Heavy Press Program.

The public record shows that construction of the *Vanguard* static test and launching platform is only one of a number of important missile contracts held by Loewy. The stability, strength and close tolerances required for large missile launching equipment is a natural for companies used the design and manufacture of heavy precision production equipment.



This exclusive shot of the VANGUARD launching platform shows Navy VIKING ready to go. Loewy-Hydropress Div. of Baldwin-Lima-Hamilton Corp. designed and built the structure.



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Would you like to learn how the "MAC Engineer" lives and plays? This pamphlet contains color pictures of typical middle-income homes in suburban St. Louis, and actual figures of cost, taxes, and utilities. With each home are pictures of nearby public schools. Also, cost comparisons are made with other areas concerning general cost of living, state gasoline tax, and state income tax. A two-year weather picture is included.

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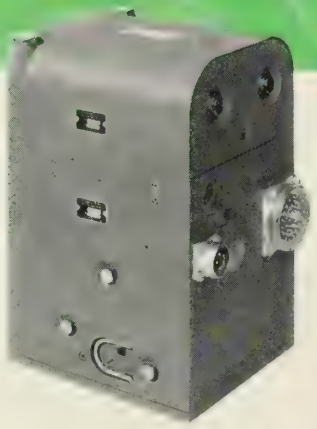
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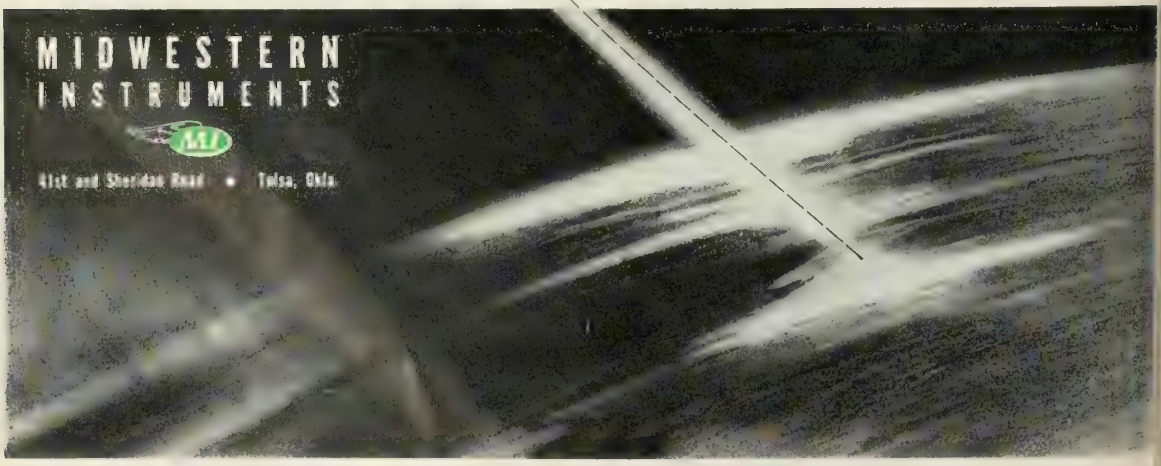


THE MIDWESTERN 561 RECORDING OSCILLOGRAPH

561 SPECIFICATIONS

Weight	15½ lbs.
Dimensions	6-11/32" x 5-3/16" x 9-3/16"
No. of Channels	14
Magazine Capacity	95' DuPont Lino Writ #4
Recording Speed Range	0.5" to 80" per sec.
Trace Identification	Beam Interrupter Type
Constant Acceleration	Above 25 Gravities
Shock Accelerations	Above 1500 Gravities for 20 Milliseconds
Temperature	—65°F to +165°F
Altitude	Up to 100,000' above sea level
Power Requirements	28 volts DC, 12 Amperes Maximum
Connectors:	
Power	WK 5 32S
Galvanometer	FK-C32-32S

This new recording oscillograph now makes it possible to eliminate costly telemetering equipment in missile, torpedo or similar testing. Its miniature size, extreme ruggedness and high recording speeds allow it to be installed directly in the test vehicle, where it will record all data and will withstand the high shocks and accelerations associated with the test.



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New Telemetry Era for ICBM'S and Space Flight

by Henry P. Steier

NEW YORK—Recognition was given at the 1957 National Convention of the Institute of Radio Engineers to the advent of a new era in telemetry, as man extends his need for radio information and remote control into outer space. A symposium on long range telemetry and remote control was featured at the convention.

M. V. Kiebert, Jr. who chaired the symposium described telemetry as a most important link in man's new search for space-knowledge.

Some years ago, Kiebert noted, he gave a paper in London, England at a joint Royal Aeronautical Society and Institute of the Aeronautical Sciences meeting, pointing out the impending obsolescence of pilots as a means of obtaining information.

As a pilot talking to pilots, he said, the statement was met with raised eyebrows and embarrassment from the audience. But now ten years later that day is here.

Some of the forerunners of pilot substitutes are already seen, Kiebert maintains, in automatic equipment on board the Boeing 707 jet transport, and when the rocket-powered aircraft arrives the pilot will be little more than the executive in charge of the flight.

Compared to future equipment and precisions, present day know-how is quite primitive. However, the first really head-on encounters with telemetry and remote control over long ranges and with high velocity vehicles are being experienced.

At this time engineers are wrestling with these experiences in military work on IRBM and ICBM test vehicles that are part of the vast R&D effort underway on these weapons systems.

A review of progress in telemetering of data from the Lockheed Missile Systems Division X-17 re-entry test vehicle was given in a paper prepared by Dr. R. J. Burke of the division, and delivered by N. Terveen, also with the missile division.

Terveen noted the relatively low cost of Lockheed's vehicle compared to an imaginary 4-passenger space ship. An airframe executive, Traveen said, has estimated the space ship would cost "$.3 x 10^9" whereas the X-17 without equipment on board costs "$.35 x 10^8," or 1000 times less.

The X-17 weighs about 6-tons. It is about the height of a four-story building and has three stages.

Before beginning with the basic tests for which the X-17 was conceived, Terveen said many flight tests had to be made to develop telemetry instrumentation and telemetry systems which would give assurance of getting back accurate data.

One difficult design area was joining the stages. The joints must be near perfect. They must take the structural loads and maintain rigidity and yet be able to separate easily.

If separation does not take place properly, the flight path or trajectory does not go as planned. Deciding whether a flight malfunction was due to poor separation or poor aerodynamic design was a problem for telemetry.

Another was determination of timing for first stage separation versus firing of the second stage. Second stage rocket nozzles when fired cause turbulence that can destroy everything in their vicinity. Instrumentation can be wiped out in a fraction of a second, and also the nozzles can be destroyed.

Instead of the usual break-wire strain gauges often employed, Lockheed used variable reluctance gauges applied to the principle tie bolts in the structure. Other gauges were used to indicate if the first stage did not return to earth after separation. What they got on the ground from this telemetry was pressure-time curves.

Each pound of instrumentation used in the third stage accounts for 140 pounds of gross take-off weight. A little over 14 pounds of such gear would mean an added ton of weight.

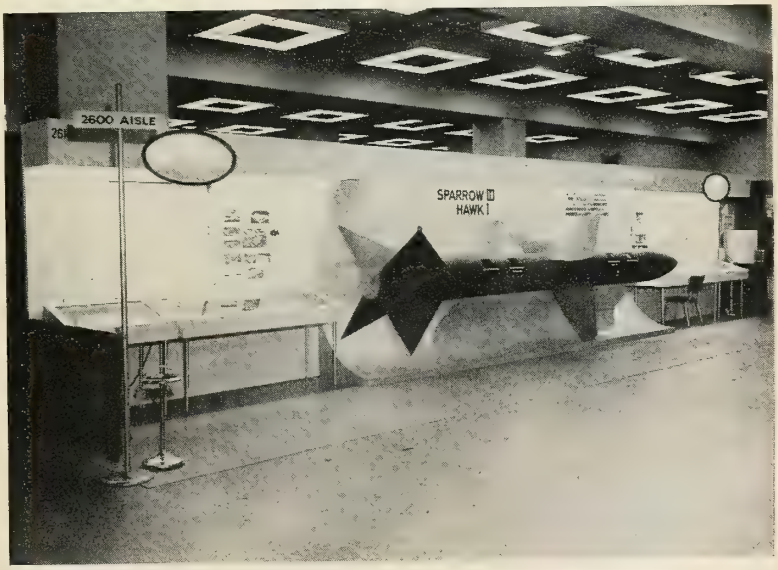
For its X-17 work, Lockheed engineers have developed a modified RDB standard commutation system that permits much better use of the inherent channel capacity by eliminating need to devote one-half the channel to signal synchronizing.

Fighting the weight-volume problem, Lockheed originally used an 11 ounce vacuum tube operated sub-carrier oscillator occupying 14 cubic inches. Now a 1¼ ounce system weighing 2/3 ounce and operating with transistors has been developed. The problem of temperature compensation was met making transistorization feasible.

Several of these have been flight tested and maintain temperature stability of less than 1 percent over the entire temperature range encountered in the tests.

The system carried aboard the X-17 is FM/FM operating in the 215-235 telemetry band. Control is by crystal and output is 2 watts.

A big part of the job of this system is concerned with temperature information from thermocouples mounted in the vehicle's nose cone.



Quiet moment near Raytheon Mfg. Co's 1½-times actual size HAWK model. Rubber tail-fin ball saved many an eager eye: Slides were shown through missile's windows.



This New 400 Cycle AC Rotary Actuator by

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Has an Operating Range of 320 to 480 Cycles ★

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A torque-limiting AC clutch is incorporated in the motor in **Type D-822** which disconnects the high inertial load imposed by the motor's armature. A brake can be built into this mechanism if **Type D-822** is altered for use in some other capacity. Another feature is the adjustable non-jamming stops that are built into **Type D-822** which are especially vital on an actuator with this load magnitude.

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SPECIFICATIONS FOR TYPE D-822

Normal operating load: 26,000 inch-pounds
Maximum operating load: 52,000 inch-pounds
Ultimate static load: 75,000 inch-pounds
Travel: 45 degrees at .625 RPM
Amperes: 4 amps. at 26,000 inch-pounds at 480 cycles on 200 volts
Weight: 35 pounds
Qualification: Type D-822 has been designed and qualified to meet applicable military and aircraft manufacturers' specifications.

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Terveen said instrumentation of the nose cone was a formidable task. The cone must be micro-smooth. The smoother the cone the more easily is heat transferred to the atmosphere during the re-entry flight.

If slight irregularities exist on the cone a "turbulent boundry layer" occurs which transfers heat to the cone at a high rate. Placing thermocouples must be done without disturbing either the smoothness or the homogeniety of the metal used.

A complex fabrication technique to do this has been worked out. Two problems remain. These are how to measure pressure at the nose cone, and what amount of metal has melted and blown away. One way to aid reduction of nose cone heating might be to remove large amounts of heat by designing for dispersal of molten metal.

An intriguing problem is what happens to radio signals that try to get through the highly ionized atmosphere around such a vehicle as the X-17.

Although Lockheed admits it has experienced a "peculiar phenomenon observed in the variation of radio frequency field strength under X-17 flight conditions" military security is close-lipped on just what has happened.

Long Range Telemetry

According to J. B. Wynn, formerly with the RCA missile test center, Melbourne, Fla. and now vice president Century Electronics Corp., significant changes in test range instrumentation have taken place in the last year.

The most noticeable changes have taken place in the case of radio telemetry equipment being installed by the Air Force at its Missile Test Center.

Whereas flight to an apogee of 100,000 feet, or about 20 miles was the maximum a few years ago, today it is realistic to talk of apogees of 300-600 miles, Wynn noted in a talk on long range telemetering reception.

At apogees near 500 miles the slant range to vehicles is around 2200 miles, and for tests on ballistic missiles achieving these ranges the Air Force has developed new high gain telemetry antennas for ground acquisition of data.

The old 2½ turn helical antenna served for five years, and in 1952 its gain was boosted to give 10-12 db by using a 7½ turn system. These gave reliable 200-mile range coverage for each site on the AFMTC range.

With the advent of ICBM tests, the Air Force now needs antennas with a 30 db gain to provide real-time data from these new, long range vehicles.

The first of these is about to begin operation. Even the longest range radars with their megawatts of power and using a beacon transponder technique for data acquisition can no longer do the job.

Their usefulness becomes even more apparent when the re-entry aspects of data acquisition are considered. In event it is impossible to pick-up data during part of the trajectory because of ionization or other interference, the telemetry system using the new automatic tracking antennas would be able to acquire data long before any other system in use today, Wynn said.

Tracking accuracies of ± ½ degree have been achieved. The lower elevation limit has been set at 2 degrees and maximum at 86 degrees.

The new antennas are big. Comparing old and new, the 2½ turn helical antennas weighed 50 pounds with a 30 inch diameter reflector dish. The new ones weigh 72,000 pounds exclusive of electronics gear, and have a 60 foot diameter parabolic dish with a possibility they may go to 85 feet.

It is certain large numbers of them will not be needed. Wynn said one at AFMTC and one in the Northern part of the East coast could cover the whole coast.

Four of the antennas will be installed by the Air Force, and this gives some idea of the vast coverage planned.

The ultimate range of the new antenna systems is believed to be far in excess of the 2200 mile figure discussed by Wynn, who was restricted by security from revealing exact range.

Electronics Designs Studied for Bombers

General Electric Co.'s Advanced Electronics Center, Ithaca, N. Y. has revealed that the company has a long range program leading to development of defensive electronic sub-systems for nuclear or chemically powered bomber vehicles expected to be operational in 1970-75.

I. Katz, consulting engineer with the Center, revealed the program at a meeting during the IRE National Convention. He said the nature of the environment surrounding such vehicles traveling at more than 2000 miles an hour will be such that wholly new electronic equipment will be needed to "see" through the interfering acoustical, chemical or nuclear radiation envelope in the wake of such vehicles.

Propulsion systems which are an-



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Honeywell
Aeronautical Division

ticipated would develop more power than the largest central power generating station anywhere in the world today, Katz said. Following the four engined vehicles will be a layer of gases at 4000 degrees R.

He predicted the noise level around the vehicle would be 190 db and inside would be 160 db. And, that an important new approach to electronic design would be required by the necessity to balance off equipment reliability against savings in weight through use of anticipated mission schedule as an index of how long the equipment should work properly.

NAA Ion Rocket Study Contract Let

The Rocketdyne division of North American Aviation, Inc., has been awarded a research contract by the Air Force to study the feasibility of ion propulsion.

Under the contract let by the Directorate of Advanced Studies, Air Research and Development Command, the division will explore ion propulsion as a possible source of economical power for missiles.

An ion propulsion system theoretically would obtain thrust by using high velocity charged particles, while conventional chemical rockets, ram jets, and turbo jets use high velocity hot gasses. Ions are atoms or molecules stripped of one or more electrons. In this form they are energized by electricity to create thrust.

Such a system would not produce anywhere near the amount of thrust developed by a chemical rocket propulsion system. At very high altitudes, an ion engine developing a few ounces or pounds of thrust might accelerate a vehicle weighing several thousand pounds to great speeds. To move the same vehicle at lower altitudes would require an engine developing thousands of pounds of thrust.

Because of its low consumption of fuel, an ion engine in theory would operate for several days or weeks. Conventional rocket engines consume fuel in a matter of minutes.

Ion propulsion is valuable only in the case of vehicles released well beyond the pull of the earth's gravity, say for example, about 24,000 miles out.

In this respect, the ion rocket would be a good second or third stage for a moon or interplanetary vehicle. Chemical rockets would provide the massive thrust needed to get beyond the immediate heavy pull of the earth's gravity.

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Frankly, we don't know about such things, and you do. That's why we come to you with a question.

What we do know is that it takes a lot of shims, laminated shims of Laminum, to build modern aircraft--because we supply the industry with custom-made Laminum shims in all shapes and sizes...in aluminum, stainless steel and in brass...so that components and structures may be accurately assembled... within limits of a thousandth, if necessary...with time-saving, cost-saving ease and efficiency.

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So...here is your invitation to get these facts--straight from "Shim Headquarters". The coupon below is for your convenience; just fill it out and mail it now.

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New subminiature sealed switch is environment-free; mounts interchangeably with MS25085



MODEL EF-3

Single Pole, Double Throw
Move. Differential, .004 Max.
Overtravel, .003 Min.
Oper. Force, 5 to 17 oz.
Release Force, 60 gram
Elec. Life Ratings:
150,000 ops. @ 125/250 V. A.C., 2.5 AMP.
100,000 ops. @ 125/250 V. A.C., 5.0 AMP.
50,000 ops. @ 30 V. D.C., (2.5 AMP., IND.; 4.0 AMP., RES.)
Amb. Temp., −65° to +180° F.

Sealed in a corrosion-resistant, treated aluminum enclosure, this tiny switch is environment-free; highly vibration and shock resistant. It carries 5 amps. at 125/250 V.A.C. with an electrical life rating of 100,000 operations. Low operating force and small movement differential make it ideal for bi-metal temperature, diaphragm operated and other "feather-touch" devices, while small size permits mounting singly or ganged in restricted space. Rugged and dependable, it has positive snap action.

Tiny, new 40 amp. basic switch has high capacity, longer life and constant stability of tolerances



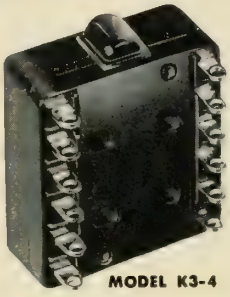
MODEL G3-8

Measuring only 1¾" x 43/64" x 43/64", the new Electro-Snap G3-8 Basic Switch handles current ratings up to 40 amps. A new method of combining Electro-Snap's double-break action with a heavy-duty switching element assures electrical and mechanical life of 100,000 cycles at large capacities; also provides constant stability of tolerances and accurate repeatability. New plastic compound case gives the switch an ambient temperature rating of −65° to +300° F. with extreme shock resistance. Small size makes it ideal for motor controls and compact automation set-ups. A wide range of actuators is available.

OPERATING CHARACTERISTICS

Single Pole, Double Throw
40 AMPS @ 125/250 V. A.C.
@ 30 V. D.C. Res.
Oper. Force, 30 ozs.
Overtravel, .025" Min.
Move. Differ., .055 ± .010

New simultaneous triple-pole switch interrupts 3-phase ac. circuits; 6-circuit control in a small package



MODEL K3-4

Triple-Pole, Double Throw
15 AMP., 125/250 V. A.C.
30 V., D.C. Res.
10 AMP., 30 V., D.C., Ind.
Overtravel, .015 Min.
Move. Diff., .028 ± .007
Mech. Life, 1,000,000 ops.
Elec. Life, 500,000 ops.

This completely new Electro-Sna triple-pole switch simultaneous reverses current flow throug three windings of a 3-phase mot up to 1 H.P. and interrupts oth types of multi-switching install tions. Instantaneous "make" ar "break" snap-action of the thr poles is independent of the spe of actuation—even extreme slow moving cams can be used.

The K3-4 Series offers designe a wide variety of 3-phase circu hookups for servo-controls, limit movement of machine mer bers and as a start-and-stop swit which formerly were possible on with complicated relays or a nur ber of separate switches. A lar selection of standard actuato is available.

New small basic switch is low cost; directly interchangeable with AN3234 Specs



F2 SERIES

The new Electro-Snap F2 Series snap action switches are extra-compact with extremely high electrical capacity for their size. Mechanical and electrical life at 1/32" overtravel is 150,000 operations, minimum, with accurate repeatability and constant stability of tolerances. Self-aligning springs provide contact wipi action rare in a switch of this size.

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SERIES F2 BASIC SWITCH: F2-3: Single Pole, Double Throw
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30 V. D.C. inductive and resistive (6 AMP, 30 V. D.C. for Airborne Applicatic
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Overtravel, 1/32 Min.

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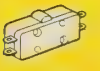
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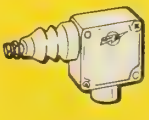
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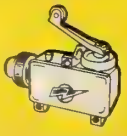
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In addition, an ion propulsion system would be extremely useful in providing adjustment thrusts for keeping a 2000-mile high manned or unmanned permanent satellite in its orbit. At such an altitude there apparently are still "earth influences" as from traces of the atmosphere and some of the micrometeoritic dust and other particles that accompany this planet through its orbit. These will be bound to slow down any artificial satellite. Ion propulsion would certainly provide sufficient thrust to prevent such a vehicle from falling in out of its orbit.

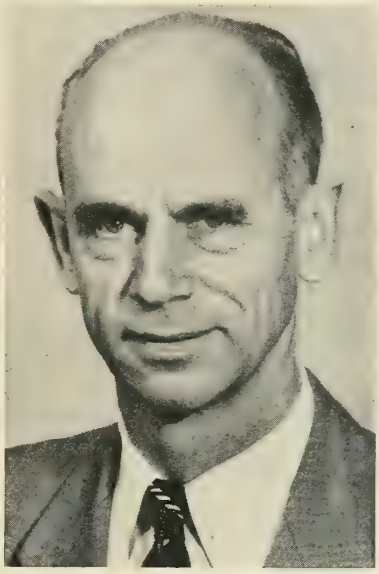
There is also the very good possibility that studies of ion propulsion will provide new knowhow that will ultimately lead to much more ambitious projects, perhaps even bearing on the basic nature or gravity.

Space Flight Confab For Businessmen

Advance reports on the "Age of Space" conference May 16th and 17th promise businessmen a practical short course in missiles and space travel.

Sponsored by the Southern Research Institute, the two-day meeting includes a *Redstone* test-firing demonstration at Redstone Arsenal.

Speakers include Dan A. Kimball, President of Aerojet-General Corp. and ex-Secretary of the Navy; Dr. Clifford C. Furnas, former Assistant Secretary of Defense, R&D; Dr. John P. Hagen, in charge of the Earth Satellite Program; Dr. Ernst Stuhlinger, Research Chief, Army Ballistic Missile Agency who helped develop the V-2,



DR. ERNST STUHLINGER

Maj. Gen. Dan C. Ogle, Surgeon General of the Air Force, F. L. LaQue, Vice President, International Nickel Co. and m/r's managing editor, Erik Bergaust, who will compare the missile science of Russia and the U.S.

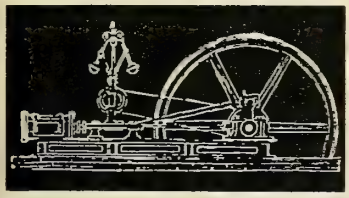
Says SRI in the conference announcement: "Glamorous-sounding—even fantastic—missiles and space travel are rapidly assuming down-to-earth importance for the businessman who is, necessarily, concerned with practicality." Meeting takes place in Birmingham, Ala.

New Missile Camera

Bell & Howell has unveiled a new missile-scoring camera pod being built under Navy contract to provide an airborne record of missile accuracy in hits and misses.

Unit is built for mounting on the wingtips of target drones, pilotless planes or larger missiles and contains four 16 mm high-speed motion picture cameras. With one pod on each wingtip, the eight cameras are mounted to give complete spherical coverage as a missile approaches the target drone.

According to B&H, the system permits missile scoring at speeds up to Mach .95 and altitudes from 5,000 to 50,000 ft. A 200-foot film capacity is said to handle up to four missile passes.



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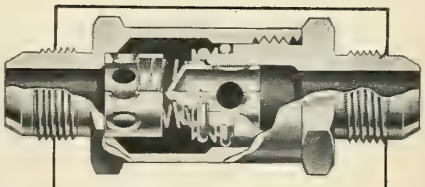
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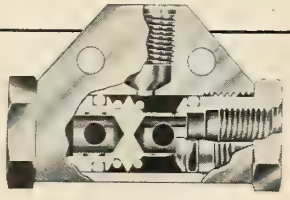
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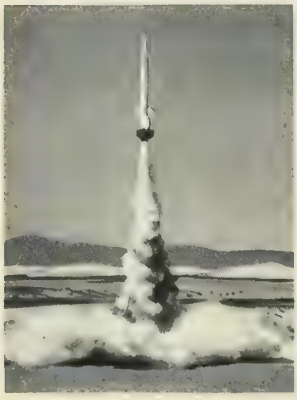
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UPPER ATMOSPHERE RESEARCH



The International Geophysical Year is a period of intensive research devoted to the earth and its surroundings. Aerojet-General research rockets will play a major role in IGY. In addition to Project Vanguard propulsion systems, Aerojet will supply its famed Aerobee-Hi rockets for critical research flights from Hudson Bay.



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Metal Congress Tells of New Materials

Materials and processes for missile applications were given much attention at the 10th Western Metal Congress of the American Society for Metals held in Los Angeles, California.

Titanium held the metals spotlight as the Metals Engineering Institute of the ASM programmed a special 5-day conference devoted exclusively to this subject during which time titanium was declared to have "arrived" as a bona-fide missile material, and increasing demands for titanium reflected its general acceptance.

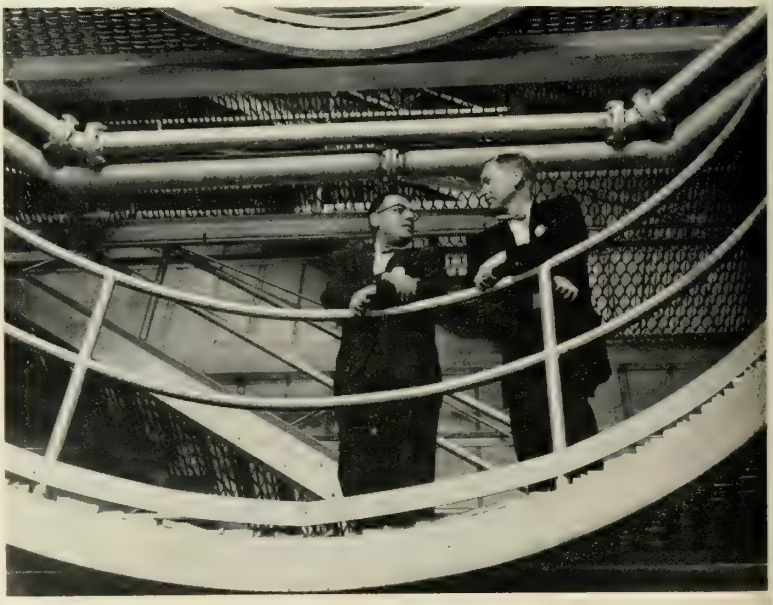
Despite increased use of titanium and titanium alloys, it was pointed out the material is no structural panacea for temperature problems encountered in missile flight above Mach 4, the point at which present titanium and its alloys become ineffective. If some method of cooling can be developed to maintain speed temperatures below those encountered at Mach 4, titanium may be used to an even greater extent. As with any material of recent development, the problem of applying it to today's designs must be solved before creating future designs based on the material's properties.

The economy of titanium in certain missile applications was declared a difficult decision, as the considerable cost expended for the weight savings gained must be balanced against the purpose of the missile. Until such time as titanium is reduced below its present cost level and new fabrication techniques are developed, designers must incorporate economy in their original concepts. Large and complicated forgings are a particular problem in titanium as forge shops do not have sufficient experience with the material. The only alternative is to machine the part from a solid billet, an extremely costly operation as the finished part may be no more than four per cent of the original billet weight of several hundred pounds.

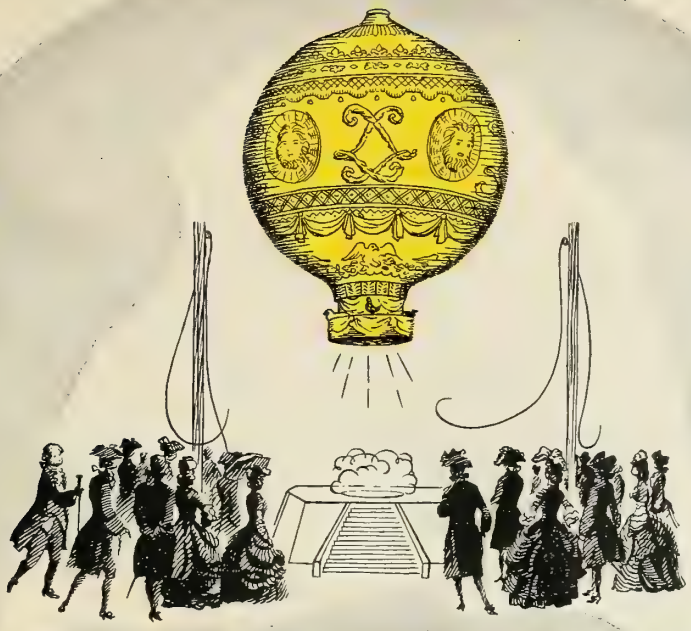
Present titanium alloys were noted as posing still another problem when used in forgings where heat treatment is required of parts with large cross sections in order to obtain maximum strength. This process changes the characteristics of the alloys sufficiently to make titanium's weight saving advantages open to question.

A discussion of titanium extrusions, as used in some current missiles, described the successful integration of the extrusions with titanium webs in box-beam construction by careful placement of rivets at the end of spotweld runs to minimize titanium's low peel strength. It is also possible to use the CHEM-MILL process to reduce web thickness overall and leave areas of greater thickness for large, load-carrying spotwelds.

Some problems of titanium may be averted temporarily by designing "around" them until a permanent solu-



Proof of progress in intercontinental ballistic missile development is in this fuel tank pressure test facility for the ATLAS recently completed at the San Diego plant of Convair Division, General Dynamics Corp. Chief engineer Mortimer Rosenbaum, left, inspects with J. R. Dempsey, Convair-Astronautics Division Manager.



Globe Aerostatique . . . 1783

Montgolfier's vanguard project

A sheep, a duck, a rooster—the first payload carried aloft for atmospheric research. Louis XVI, his queen and his court, were astonished witnesses as Joseph Montgolfier's smoke-filled balloon rose in majesty 1500 feet over Versailles. The passengers? unharmed (except the rooster, kicked by the sheep).

Project Vanguard, 1957, is an equally momentous "first"—an attempt to place a 21-pound satellite in an orbit 300 miles up. Aerojet-General, designer-builder of the famed Aerobee-Hi, will supply vital second-stage propulsion systems for Vanguard launchings during the International Geophysical Year.

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missiles and rockets

tion is developed, it was declared. One of these is the relatively large minimum bend radii tolerated by existing titanium alloys, with new alloys expected to require an even larger radii and increasing the weight of the formed part. To anticipate this, new techniques such as creep-forming and hot forming are undergoing further study. Titanium alloy (6AL-4V) sheet is being formed successfully by the use of resistance heating and ceramic lubricants, but contamination and distortion are still critical in heat treatment of light gage sheets. Machined extrusions and welded angles are being used also to overcome forming problems.

Both resistance and fusion welding were credited with taking an ever-increasing part in missile applications of titanium, but the problem of providing an inert gas shielding during welding demands the component be designed with both sides of the weld accessible during fabrication. The accuracy of long resistance welding times, required in some applications, has been improved by incorporation of digital counting systems based on the British-developed Dekatron, a cold-cathode counting tube.

Titanium Users Cautioned

Titanium users were cautioned that although titanium has an unusual weld joint efficiency, only a few of the available titanium alloys are acceptable in welded structures for missile applications, and welding techniques should be rigidly controlled as no satisfactory non-destructive test of weld quality has been developed.

Tests of welded titanium were described as indicating welded joints of pure titanium and alloys containing primarily alpha stabilizing elements are not adversely affected by high temperature aging, but welded joints of alloys containing primarily beta stabilizing elements are extremely adversely affected by the same conditions.

The application of titanium in missile cooling tubes and heat exchangers was cited as an example of brazed components, although it was admitted that all problems in brazing titanium had not been solved.

The phenomenon of "creep," or flow of metal under heat and stress, was charged with being a principal factor limiting the use of titanium in missiles. Two of the newer titanium alloys containing aluminum, 6A1-4V and 5A1-2.5Sn, were said to have more creep resistance than eight per cent manganese titanium alloy, but exact data has not yet been determined to afford full application of these materials. Special equipment is being developed to obtain short-time, high-speed, high-temperature "creep" data by resistance heating at rapid rates and recording the results with special extensometers.

The problems of thermal expansion of titanium and titanium alloys were considered to present the designer with no more difficulties than any other material or material combination.

One property of titanium and its alloys detrimental to missile electronic application was described as its low electrical conductivity. When operating conditions rule out the use of any other structural materials because of weight and heat resistance requirements, titanium may be plated with a precious metal of high conductivity at little increase in cost or weight.

In spite of many excellent characteristics, titanium and its alloys were again described as not being the best possible materials for missiles from a structural-stress basis. This was attributed to the many types of load factors under which a missile component may be required to operate, and the many forms or shapes in which it may be used. However, work is continuing on the material efficiency curves for newer alloys which may be heat treated to



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higher strength levels, and it is expected the new curves will be considerably higher than those of the much-in-use eight per cent manganese titanium alloy.

Several papers presented to ASM members dealt with progress in methods to determine mechanical properties of structural materials as applied to missiles. Nearly all outlined the rapid heat, rapid strain rate, and short temperature holding time approach to their investigations.

Molybdenum-Titanium Alloy Strong at High Temperatures

Other materials discussed briefly in relation to their missile applications were a molybdenum-base alloy containing .5 per cent titanium, which is claimed to have a higher useful strength at temperatures over 1600°F than any other presently known material, and precipitation hardening stainless steels.

Liquid propelled aircraft rockets were given a boost in a paper presented by Walter S. Tenner and Paul T. Barnes of the Naval Ordnance Test Station. Described as a "5-in., high-velocity, unguided, air-to-air rocket, the LAR (Liquid Aircraft Rocket) is propelled by liquid bi-propellants, although a solid propellant commonly is used in small rockets."

"The performance of liquid rocket propellants," Tenner said, "has many advantages over that of solid propellant rockets. The principal disadvantages are problems of 'hardware' and assembly.

"Since the originally used mechanical joints were unsatisfactory, welded joints were developed for some areas.

"A program was then initiated to determine the feasibility of welding the entire missile. Early tests indicated the use of an automatic welding process would be necessary to attain the desired results.

"Prototype welded missiles were fabricated and fired successfully."

The LAR is in the pilot production stage and, with simplified hardware assembled by welding, is claimed to be competitive in cost with solid-propellant rockets. Its performance was declared to be "outstanding."

Non-destructive testing was the subject of another large group of papers in which the use of X-ray, eddy currents, ultrasonic flaw evaluation, magnetic particle inspection, isotopic examination, fluorescent penetrants, and nuclear studies were described as finding wide application in the missile and rocket field.

RIAS Wants Sphere 2000 Miles in Space

RIAS, Inc., a subsidiary of The Glenn L. Martin Co., last month proposed firing a recoverable 150-pound sphere 2000 miles out into space with the idea of using emulsion sheets for measuring cosmic energy in free space. Basic proposal consists of stripping a vehicle like *Vanguard* of all guidance and special satellite launching gear and shooting it straight up.

That way, Martin designers W. J. Benckert and R. T. Patterson figure, both payload and terminal altitude could be materially increased over that hoped for from *Vanguard.*

Of the total 150-pound sphere, only about 50 pounds would be available for scientific payload. The rest would consist of an outer shell to take the brunt of reentry. Presumably it would be made of a material that would dissipate heat by melting and/or sublimation during initial reentry and deceleration. In addition the sphere would contain a parachute (or series of them) for lowering the payload to earth unharmed. It would also include a radio beacon for locating it on the ground.

It's estimated that it would spend 40 minutes above the atmosphere and attain a top speed of 13,000 miles per hour on reentry. Analysis of the emulsion sheets to determine the nature of primary cosmic radiation in space would, Martin estimates, require several months of work by a hundred or more research workers.

This is a hypothetical proposal by Martin, since no contract now exists for making the attempt.

Bristol Develops Practical Missile

Bristol Aircraft Ltd. reports the development of "an entirely practical" missile (probably a SAM, according to the Society of British Aircraft Constructors). Bristol made this statement when the Ministry of Supply authorized the release of a photograph of an early Bristol supersonic vehicle known as *Bobbin.* Now some years old, this device was developed for test work on guided weapons and on Bristol's *Thor* ramjet engine.

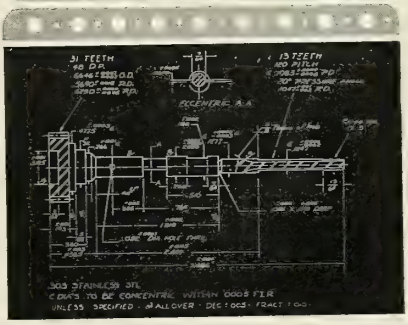
Bristol has released a limited amount of information on the testing of *Bobbin.* It had a long, spiked nose which stuck into the ground on landing. Supersonic parachutes, developed by the Irving Air Chute of Great Britain and G. Q. Parachute companies, slowed *Bobbin* down from very high speeds so that when it landed on its nose spike, it was virtually undamaged.

The parachutes themselves underwent novel tests over Salisbury Plain, in Wiltshire, before being fitted to *Bobbin.* A dummy test vehicle was dropped from a *Canberra* at very high altitude and accelerated in free fall to well above the speed of sound—producing a sizeable sonic bang. Six ribbon parachutes were released by time switch before, their work done, they were jettisoned automatically. In falling away, they drew out a 30 ft. nylon parachute which lowered the test vehicle gently to the ground. In this way, *Bobbin* became the first British-designed recoverable test vehicle.

Tests to design and manufacture the long nose spike were performed by using a dummy vehicle which was dropped vertically from a crane. Decelerometers and high-speed cameras measured the rate of impact. To establish how the nose spike would react to various types of terrain, half-scale models of the test vehicle were dropped from a helicopter over the Woomera range in Australia.

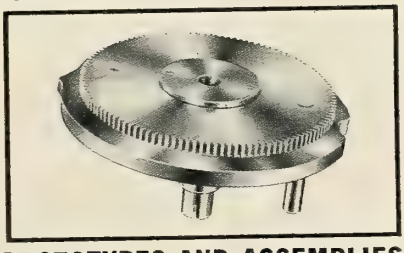


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North American's X-10 Ends Successful Test

ERRONEOUSLY LISTED as dead, North American Aviation's *Navaho* is still a very much alive project. While the contract has been terminated on the intermediate XSM-64, the basic contract for a successor air-breather to the Northrop *Snark* continues in force (see Industry Highlights, p. 144). Meanwhile the program has not been without its benefits.

NAA's retrievable X-10 has been applauded by the Air Force as an "invaluable source of important data." Announcement that the missile-on-wheels had wound up a series of successful test flights was made early this year. It was flown hundreds of miles at supersonic speeds under full automatic control to prove out its design and guidance systems.

The X-10 is powered by two turbojet engines. Its landing gear makes it recoverable for repeated use.

This vehicle is part of the SM-64 *Navaho* weapons system research and development program. Earlier the 14-foot *Nativ*, a single ballistic missile, was successfully tested.





X-10 lands smoothly—coming in with nose high, easy touch-down. Note position of canard stabilizer. X-10 has been applauded by Air Force as "invaluable source of important data."

The *Navaho* weapons systems program goes back to 1945. *Navaho* is one of the most controversial missiles of the day. Big question mark: How good is an aerodynamic intercontinental missile in tomorrow's hypersonic age? Another one: Is the *Navaho* a competitor of the *Snark* or vice versa and can we afford both? Ballistic missile enthusiasts may think there is no need for a *Navaho* but General Curtis LeMay seems to think differently. He wants a long-range missile while waiting for the ICBM.

Now in advanced stages of development, *Navaho* flight testing was undertaken at the USAF Missile Test Center, Florida.

Design and manufacture of the *Navaho* guidance and control systems is the responsibility of North American's Autonetics Division. A third division, Rocketdyne, builds rocket engines for the missile, which will be rocket-boosted to flying speed and then powered by ramjets.

Work on the *Navaho* has been underway for some time in North American's Missile and Control Equipment operations (MACE) at Downey, Calif. MACE operations involve major phases of missile airframe design, rocket engine propulsion, automatic guidance and control equipment. North American says its MACE technical force "is being expanded greatly."

NAA's Missile Development Division started in 1946 with a few men working in a corner of the company's Los Angeles plant. Today the Missile Development Division has grown to about 7,000 workers.

The company began experimental work late in 1947 after completion of studies in airframe, and propulsion. These included possible nuclear power and automatic guidance and control systems. In May, 1948 the first research missile was sent up at Holloman Air Force Base, N. M. This was the *Nativ* and eight of these were built and flown. The staff soon outgrew its Los Angeles quarters and moved to its present location in Downey.

In 1950 the SM-64 *Navaho* missile project was born.

Growing out of NAA's Missile Development Division were: The Autonetics Division, Atomics International Division and the Rocketdyne Division. The four divisions today employ nearly 25,000 persons and have earned for North Amercan the reputation as "the country's best integrated and probably biggest missile research organization."+

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HDMP4 HDMP4A*	400	500	280	350	1	150
HDMP5 HDMP5A*	500	625	350	320	1	130
HDMP6 HDMP6A*	600	750	420	300	1	115
HDMP7 HDMP7A*	700	850	490	280	1	100
HDMP8 HDMP8A*	800	950	560	265	1	80
HDMP9 HDMP9A*	900	1050	630	250	1	65
HDMP10 HDMP10A*	1000	1150	700	240	1	50

Note 1 — Measured at a reverse current (I) of 0.1 mA
Note 2 — Cathode is electrically connected to the case
* — Axial lead types

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Rocket Trends



By Erik Bergaust

Even the experts seem to ignore what's wrong with our intermediate-range ballistic missile program. Certainly, the problem is not the otherwise harmful interservice battle between the Air Force and the Army. However, the seemingly ignorant high-echelon orders and rules on roles and missions, that have caused this Army/Air Force controversy, will determine something more important by far. They will determine if we will win or lose the race with our potential enemies.

It has been our privilege to discuss this serious problem with top military leaders. We have interviewed secretaries, generals and admirals for hours and hours—and have traveled thousands of miles to get the true story—and have found that the Air Force is doing a terrific job on the most important of our current missiles, the ICBM. In fact, the prototype of the *Atlas* ICBM is being readied now for its maiden flight. (It might have flown by the time this issue of m/r reaches its readers. *More than a dozen Russian submarines were spotted off the coast of Florida as m/r went to press.* Navy blimps are busy watching the unwanted visitors.) Could it be this accomplishment is based on the fact that the ICBM program has never been hampered by interservice rivalry? Apparently the *Atlas* ICBM now is in a more advanced stage than the *Thor* IRBM. Likewise, we have found there's no doubt about the Army's IRBM capability. The Army's ballistic missile capability is so excellent it is possible that they will demonstrate it by sending a space satellite into an orbit around the earth early this summer.

We have discussed the ballistic missile program with senators and congressmen. Says Sen. John D. Sparkman: "Let the Army develop the *Jupiter*, the Air Force the *Thor* and the Navy the *Polaris*. In a future war, we'll need all of them." Certainly, the Air Force should have an IRBM. On the other hand, it is utterly ridiculous to knock out the Army, because the Army has a *requirement* for this kind of *long-range artillery* if it is to stand up against Russia in a future atomic war.

This is why we must have a full-fledged IRBM program, and we cannot afford to cut it short now. Because the real problem is Russia. What are we doing about the fact that the Communists launched a 650-mile operational ballistic missile (the *Comet*) two years ago? From submarines! Are we overlooking that the Russians now have operational IRBM's? And that their missile subs have been spotted off our coasts? When will we wake up to reality and comprehend that the Russians carried out a full-fledged missile research and development program with intense eagerness (from 1945 to 1950) before we even started to think of any accelerated high-punch missile projects? Who are the military leaders in this country who dare kill any ballistic missile project, as long as only a handful of *Thor* and *Jupiter* prototypes have been built, and it takes at least one year to get an evaluation, and two or three to get them into production?

That's what is wrong with our IRBM program. The fact that we're trailing Russia—dangerously. This is the issue. But it appears our defense leaders do not want to understand this. And another thing: this absolutely fantastic idea that has been played in the press lately, that this country is about to provide Britain and possibly France with intermediate-range ballistic missiles! Let's stop fooling the public. We don't have any such missiles. They are two or three years away. We might get them sooner if the services were given the go-ahead on a sound competitive basis—without being hampered by morale-breaking, nerve-racking policies. (We have learned reliably that the "give-away" IRBM will be a *Thor* with *Jupiter* guidance.) Such policies never serve any useful purpose. And certainly not now, when the most important of all battles is being fought: the technological race between this country and Russia.



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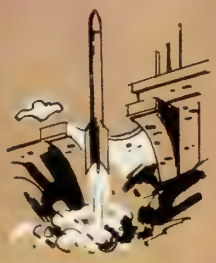
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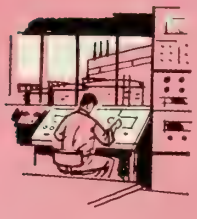
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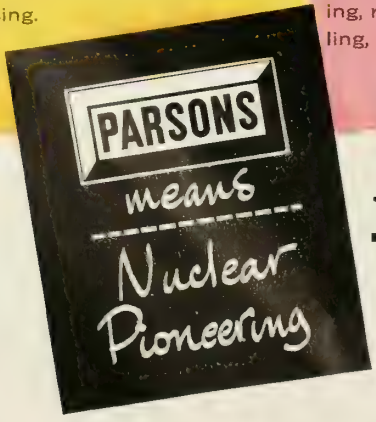
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missiles and rocke



Washington Spotlight

By Henry T. Simmons

Final determination of the fate of the North American *Navaho* ramjet missile will be made by the Air Force next fall. As of now, it appears that two principal conditions must be met if the intercontinental weapon is to go into large-scale production: It must make an excellent showing during current tests at Patrick AFB, Fla., and unexpected roadblocks must crop up in the ballistic missile development program. Furthermore, they must be serious difficulties—bad enough to delay introduction of the ICBM three years or more beyond the operational date expected for the *Navaho*. Any lesser delay would probably persuade the USAF to step up production of the Northrop turbojet *Snark*.

•

Even should everything favor increased support of the *Navaho*, there remains the knotty problem of where to find the money. If really serious troubles hamper the ICBM, of course, funds can be withdrawn from that program and applied to *Navaho*. But the North American weapon will still be just one of many projects clamoring for money. Probably its most important competitor will be the WS-110A intercontinental chemical bomber projected by the USAF as a replacement for the B-52. NAA and Boeing are expected to submit their WS-110A entries about June, with an Air Force evaluation several months later. Should really tough problems arise in the ICBM program, the Air Force may be more inclined to fall back on a traditional manned bomber concept rather than strike out into new and unfamiliar production, maintenance and operational territory with the *Navaho*.

•

The Air Force is still studying the failure of the *Thor* IRBM on its maiden flight at Patrick early this year. The trouble was apparently caused by a recalcitrant valve in the engine starting system. Probably because of an explosion which occurred when the liquid oxygen came into contact with an impurity in the valve, the valve itself failed to close tightly. This permitted a portion of the LOX which should have gone to the engine to recirculate, thus starving the combustion process so that the rocket sagged back to the ground. The airmen hope to duplicate the exact circumstances of the accident.

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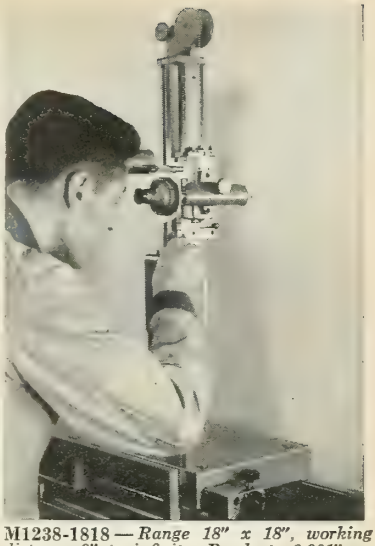
Army procurement of guided missiles is heading upward even faster than in the Air Force. The soldiers expect 50% of their total procurement funds will go for birds in fiscal 1958, beginning next July 1, compared with 23% just two years ago.

•

Although the existence of a guided missile called the *Corvus* has been known for more than two years, it was not until last month that the name could be nailed to a specific project. It seems that a $16 million Navy contract awarded Temco in January provides for design and development of the weapon. *Corvus* (Latin for Crow) is a long-range air-to-ground missile to be carried by a brand new Navy attack fighter for which a competition has just been established. It is believed the Temco weapon is a descendant of Fairchild's *Lark* research missile.

•

Rep. Carl Vinson (D-Ga.) has scotched chances for an early hearing on the *Thor-Jupiter* by his House Armed Services Committee. Rep. George Huddleston, Jr., (D-Ala.) had urged a secret hearing on the IRBM program, but Chairman Vinson said it would not be wise. "I am mindful of the pending court martial action which has a direct bearing on this matter and I feel this committee must do nothing that could prejudice the court martial in any way," he wrote.



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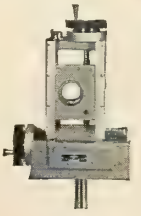
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VOL. 2 NO. 4

APRIL, 1957

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

m/r exclusive:

USAF's Long-Range Missile Program

IT HAPPENED in the early evening of September 6, 1944. People of Chiswick-on-Thames, London, had just finished their evening meal. At 6:38 this evening, at Wassenaar, on the outskirts of The Hague, Netherlands, the first military rocket capable of approaching a predetermined target at a speed greater than sound and with no advance warning was launched. It was an awesome weapon, forty six feet in length, and weighing 2,200 pounds. Its speed was 3,500 miles per hour, and at the height of its trajectory it reached a point 50 miles above the surface of the earth. It was an all-weather weapon, and most fearsome of all, there were no counter-measures against it. The effect was devastating. The people of Chiswick-on-Thames felt it. For this was the first "target" to be hit by a liquid-propellant ballistic missile.

The dramatic launching of the first rocket attack in history was born of desperation on the part of Hitler. Following early and easy victories in Poland and France, Germany suffered defeat in its efforts to conquer England by air attacks. This set-back was followed by collapse of the German invasion of Russia. Clearly, something desperate was necessary, and the rocket seemed to be the answer. Following the initial rocket offensive 26 additional missiles were directed toward London during the next ten days. Between September 1944 and March 1945, approximately 1,500 V-2 rockets were showered on England.

Thus, comments after the war by leading military figures, that such an offensive, if perfected in the early days of the war, could well have defeated the Allies. General Eisenhower, writing in his book, Crusade in Europe, stated "It seemed likely that if the German had succeeded in perfecting and using these new weapons earlier than he did, our invasion of Europe would have proved exceedingly difficult, perhaps impossible. I feel sure that if he had succeeded in using these weapons over a six month period, and particularly if they had made the Porthsmouth-Southampton area one of their principal targets, 'Overlord,' (codename for the planned cross-Channel invasion of France), might have been written off."

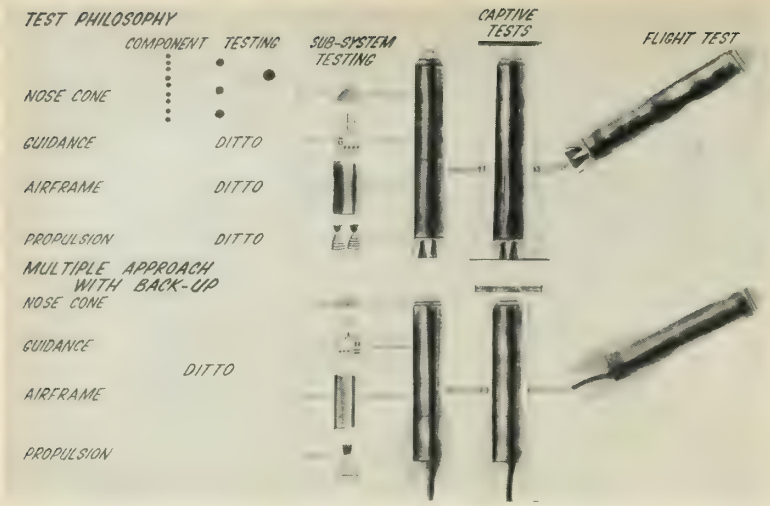
This article on the history and development of long-range ballistic missiles, and the role our Air Force plays in the important ballistic missile race with Russia, outlines the philosophies behind long-range missile weapon systems as well as some of their psychological effects on our society. The article was prepared by m/r managing editor, Erik Bergaust, and Vincent B. Hackett, Field Engineer, Telecomputing Corporation.

In the years immediately preceding the outbreak of war, one of the most closely guarded secrets in Germany was the experimental work being done in the field of ballistic rockets.

Early in 1930 General, then Captain, Walter Dornberger, Dr. Ernst Steinhoff and Dr. Wernher von Braun were busily engaged experimenting with the theory of such missiles for the German Army Ordnance Corps. In March of 1936 Colonel-General Werner von Fritsch, Supreme Commander of the Army, was persuaded by Dornberger and von Braun to visit the early experimental station in Kummersdorf to inspect the work under way. This visit resulted in an allocation of funds for future experiments, and a decision to approve von Braun's plan to move all operations to an isolated spot, previously selected by von Braun, on the coast of the Baltic Sea. This occurred in 1937. The new location, Peenemünde, was destined to become a source of prime interest to the British High Command before the war was brought to an end.

Hitler was showing enthusiasm over the progress developed in the missile program. In June 1943 he visited Peenemünde to observe first hand what might be expected. Already desperate, he visualized the possibility of opening a decisive attack on England by a new and terrifying vengeance weapon, which might serve to prevent any plans of crossing the Channel into France.

He left Peenemünde determined on all-out effort as a new and final effort to create panic among the Allies. Evidence of this desperation is afforded by his statement to German military associates on June 10th that, if the



Western Development Division's test philosophy for the two intercontinental ballistic missiles Atlas and Titan. Convair's Atlas is being readied at Patrick AFB for its maiden flight test; Martin's Titan—which got under way later than the Atlas—may fly at the end of this year.

German forces would hold on for a short time longer, London would be razed and England would be forced to surrender. He gave the date of October 30th as the date for the beginning of such attacks. It is said that Hitler ordered 30,000 rockets for immediate production, thereby indicating the degree of confidence in the new weapon. It was an unrealistic program. One thing was evident. Hitler planned to rain rockets on London in a desperate effort to bring England to her knees. England's duty was clear—crush the new menace at its origin, Peenemünde.

On the night of August 17th, 571 heavy RAF bombers struck from a level of eight thousand feet. This sorty resulted in the loss of forty aircraft, but the results were worth the loss. Drawings due to be issued to the workshops were burned, 715 personnel were killed, including Dr. Thiel, the commanding military officer.

Reports from Britain indicate that over 1,000 V-2's alone fell in and near London over a period of seven months. The number of homes and buildings destroyed ran into the tens of thousands. Only due to the fact that the Canadians in March 1945 captured the launching sites in Holland was much greater damage and loss of life prevented. There is no record that a single V-2 was intercepted or shot down once under way.

According to Dornberger, 9,300 V-1's were fired day and night against England—about 6,000 reached the English coast—4,300 V-2's were operationally directed against England and over 2,100 against other targets. The last V-2 fired was on March 27, 1945 at 4:45, and its target was Orpington in Kent. This last rocket was the 1,115th to fall on England—Casualties for the entire period of firing was 2,511 killed; 5,869 seriously wounded in London, and 213 killed and 598 seriously wounded elsewhere, according to Dornberger.

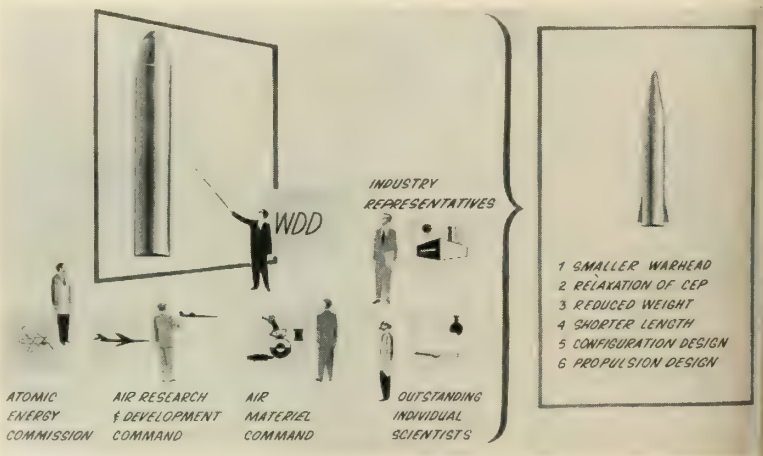
The history of the V-2, the world's first ballistic missile weapon, and the statistics on death and destruction caused by this weapon, clearly indicated that this kind of missile was here to stay—that highly advanced ballistic missiles would be included in any modern defense system. As a matter of fact, the art of missile science has advanced so rapidly since the days of the V-2 that 50% of the USAF budget will go for missiles within the next two or three years. And Russia puts an equally great emphasis on these weapons. There are, in fact, indications that the Russians might be ahead of us in many phases of missile development. Some of her ballistic missiles have already reached the production stage . . .

America Takes Advantage

Project "Paper Clip" has meant a lot to American technological and scientific advancement. This was the program under which top notch German scientists were taken to this country. Ballistic missile know-how was brought to the United States and the US Army could establish an important ballistic missile program. American industry, thus, became familiar with the art. The need for missile engineers turned into a boom with more need for specialized training and education. During the last 12 years a whole separate industry has emerged from the early backyard experiments that took place at White Sands with captured V-2s.

In 1946 the Air Force assigned to Convair a research contract for Project MX-774, in a sense the predecessor to the *Atlas*. But the early project was cancelled out one year later, in 1947, because of the Defense Department's economy "review" of this and other seemingly "unnecessary" weapon system concepts. Of course, the Air Force knew only too well that this was dangerous. They watched how the Army proved the feasibility of ballistic rockets. They knew the Russians were working on long-range ballistic missiles. They knew it was necessary to carry out an intercontinental ballistic research and development program. Obviously, the Air Force would have to become the service in charge and control over long-range missiles, eventually. This weapons concept was nothing but strategic bombing.

In 1951 the Air Force came into the act again. And this time top Air Force planners played their cards so



The Air Force' ICBM programs represent a great industrial challenge. This illustration shows the military and civilian elements involved.

that it would never again be possible to kill any phase of the projected ballistic missile program.

Thermo-Nuclear Break-through

The Air Force ballistic missile program encompasses the largest concentration of men, money and materiel on a science-industry military basis that has ever been achieved. The end product required—an operational intercontinental ballistic missile at an early date.

The thermonuclear break-through in 1952-1953 was a major break, according to WDD Chief, General Bernard A. Schriever. The possibility of high yields in reasonable packages meant that accuracy requirements could be relaxed, that it was now technically possible to develop a reliable guidance system, and that the overall weight of the missile could be considerably lessened.

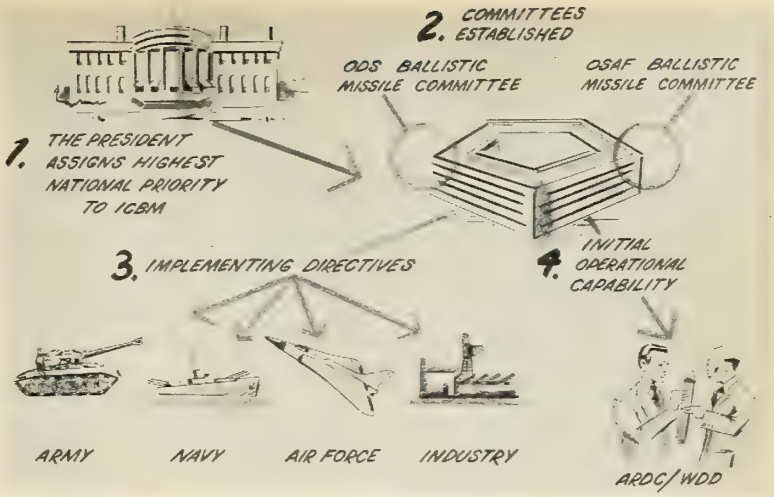
In August 1954, the Western Development Division of Headquarters ARDC was established in Inglewood, California. WDD was to have responsibility and authority over all aspects of the program with the specific purpose of reorienting and accelerating the ICBM program in order to achieve the earliest possible operational capability.

By January of 1956, the Air Force Ballistic Missile Program had been expanded to include the IRBM *Thor*. The ICBM program already had under development all the subsystems such as propulsion, guidance and nose cone, which were required for the *Thor*. Therefore, only the Douglas Aircraft Company, which has the airframe, assembly and test responsibility, was added to the list of industry contractors. Tapping the ICBM program provided a special opportunity for maximum saving in development time and money.

The establishment of WDD by the Air Force was indeed a unique and important management step. It marked the first time that the Air Force would retain full and complete management responsibility over a major development effort.

The concurrent development and production of the Air Force's Ballistic Missile Program under the management of an overall team is an integrated approach without precedent. The program is on schedule. Milestones are being met and the WDD Chief is confident that they will continue to be met.

The Air Force firmly believes in the policy of utilizing the demonstrable effectiveness of all elements of U.S. science and industry. Accordingly, the strongest scientific - industrial - military team possible has been assembled by the Air Force in all fields of ballistic missile requirements in support of this, the nation's highest priority program.



The President of the United States has assigned top national priority to the ICBM program —overall simplicity for conducting the program is emphasized.

Without this philosophy and without the wholehearted response of science and industry, the task could not be accomplished.

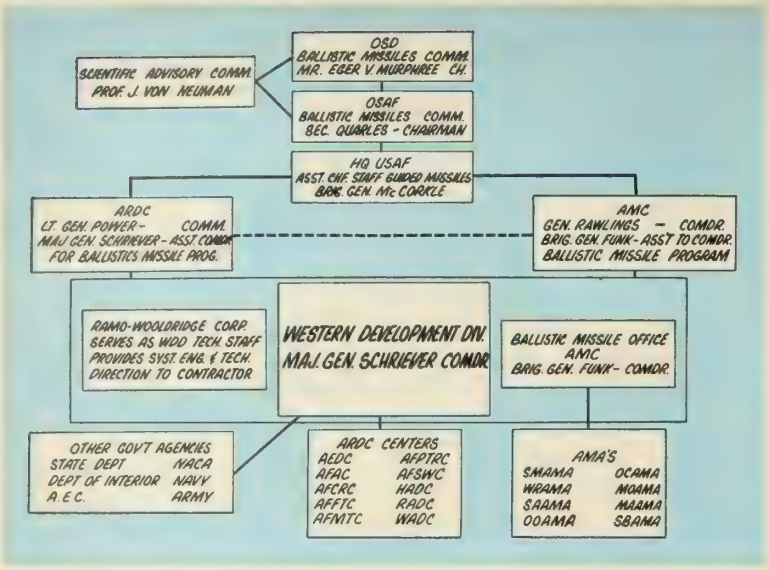
USAF Missile Management

Three elements are making up the total Air Force long-range missile systems organization management; first, the Western Development Division, which is part of Headquarters, Air Research and Development Command. WDD has the overall responsibility and authority for the program and supervision of the management complex. Secondly, the Ballistic Missile Office, which is part of Headquarters, Air Materiel Command, performs all the contracting activities of major contractors and administers the contracts.

The Ballistic Missile Office supports the operational activity in terms of maintaining supply records, procuring the necessary level of spare parts,

THE TWO DECADES OF BALLISTIC MISSILE DEVELOPMENT

1937	German Army Activates Ballistic Missile Program
1942	First Ballistic Missile Flight—German V-2
1944-1945	6000 V-2s Produced 3600 V-2s Launched At Allied Targets
1946	Russia Accelerates Ballistic Missile Program V-2 Program In This Country Reaches Peak USAF Project MX-774 Study Contract (Convair)
1947	Defense Department Economy Review—MX-774 Cancelled
1951	USAF Project MX-1539 Second Study Contract (Convair) ICBM Program Initiated—Convair *Atlas*
1952	*Atlas* Component Program—Seven-Engine Design Gets Underway
1952-1953	Thermo-Nuclear Breakthrough
1953	USAF Establishes Strategic Missiles Evaluation Committee, Dr. Von Neumann, Chairman US Army Fires First Redstone Ballistic Missile
1954	USAF IRBM/ICBM Program Is Accelerated
1955	USAF Starts ICBM Component Tests
1956	Russia Fires *Comet* IRBM From Submarine
1957	US Starts Flight Test Program For IRBMs and ICBMs



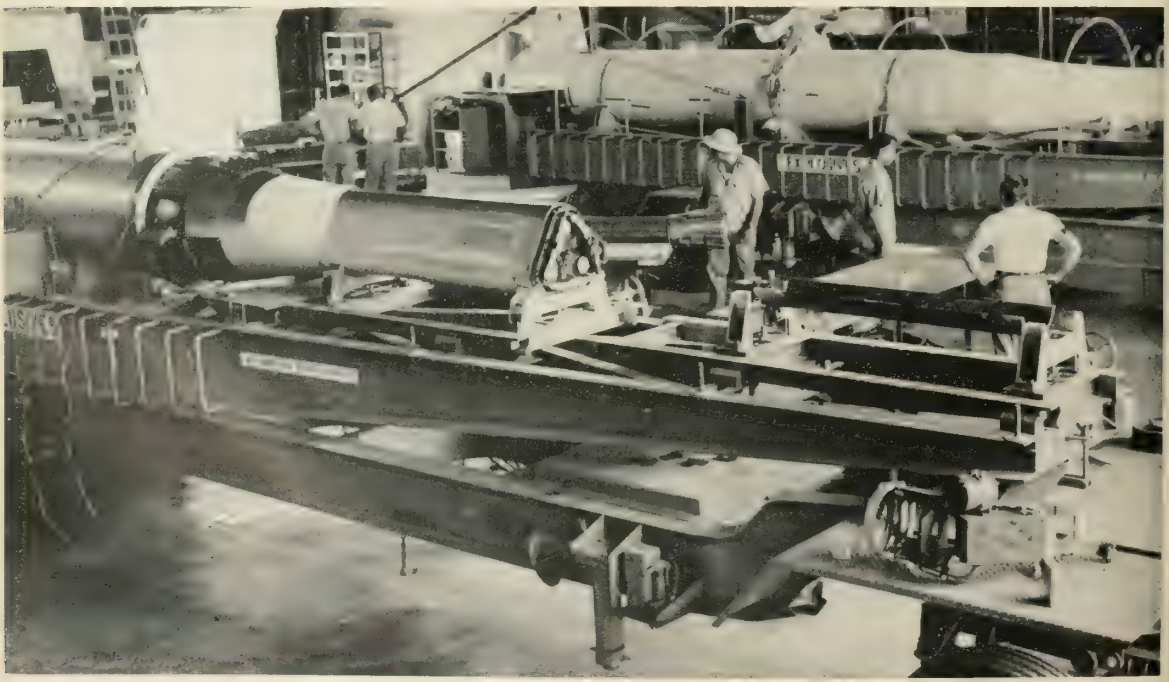
Organizational chart showing the various functions and the jurisdiction pertaining to the Air Force long-range missile projects.

establishing maintenance procedures and affecting necessary transport of parts and missiles.

The third element is the Guided Missile Research Division of The Ramo-Wooldridge Corporation, which has the systems engineering responsibility. The Air Force has found it necessary to have a systems engineering manager to integrate the subsystems. For example, the same basic power plant that powers the *Thor* missile also provides the basic propulsion element for the *Atlas*. For the *Atlas* the Air Force uses a combination of engines, while a single engine is used in the *Thor*. From the standpoint of the thrust chamber and most of the basic plumbing and what goes with it, the engine is the same. The nose cone is being developed by General Electric and will be used both on the *Thor* and the *Atlas* in the early operational missile. Later on there will be different specification, but the approach under development will get the Air Force there quicker. In the guidance area Bell Telephone Laboratories has the radio inertial guidance system contract—this guidance system will be used both for the *Titan* and the *Thor*. Consequently, the Air Force has to centralize the technical direction of contractors to be sure the BTL system is compatible to both the *Thor* and the *Titan*. The Air Force could not delegate down to Martin and to Douglas; it needs an "umpire," because they will run into differences, naturally. For instance, one contractor will want something just a little bit different than the other one. That is why the Ramo-Wooldridge Corporation was called upon to monitor the program. So far, this has worked fine. And the Air Force actually is *ahead of schedule* on several of the evaluation and test phases of the ICBM program.

Certainly, the Air Force has come a long way. The Air Force and American industry have proved that practically any technological challenge can be met. Yet, many experts question whether we are so well off in comparison to Russia. But this might be a result of getting the program underway late, something which is dictated by

Two X-17 reentry test vehicles at Lockheed's facility at Patrick Air Force base being assembled on the strongbacks which will carry them to the launching pad. X-17 plays important role in the Air Force long-range missile research and development program.



politicians. The Air Force cannot be blamed for this.

Nevertheless, the Air Force has been pushing these programs hard, and we are now reaching the point when even Air Force spokesmen talk about using ICBM hardware for the purpose of sending rockets to the moon—as part of the ICBM training program for launching crews.

A Military Leader and Sound Industrial Planning

The Air Force's eagerness—from an early date—was inspired by General Bernard A. Schriever. He has been pushing the program hard—and being the born leader, he has truly built the backbone of the Air Force ballistic missile program. He is charged with the responsibility of keeping the Air Force on the right course, at the right speed —and well ahead of our potential enemies.

However, let us not forget that the Air Force Ballistic Missile Program is a typical American *industrial challenge,* and that the Ramo-Wooldridge Corporation, as program monitor and engineering manager, has contributed much to the advancement of the projects involved. R-W is actually a typical American firm—although its functions in the Ballistic Missile Program are unique.

The record of the company in this work, on behalf of the national defense effort, has been unusually good. One of the reasons — possibly — is that the Ramo-Wooldridge Corporation at its inception sought and succeeded in establishing a close liaison with Thompson Products, a typical American "big business" firm.

A measure of the importance which is given by Thompson Products to its affiliation with The Ramo-Wooldridge Corporation is the fact that under arrangements existing between the two companies, R-W has access to funds in excess of $20,000,000 to finance its operations and expansion requirements for the next few years.



The main areas of ICBM design and development include propulsion, airframe, staging, reentry and warhead. Air Force seeks to employ overall simplicity, standardizing engines, nose cones, warheds.

While control of the company is vested in the hands of its key employees, the assistance provided by Thompson Products is not limited to the extensive financial backing it provides. In addition, the business and industrial experience and services of this large organization are made freely available to Ramo-Wooldridge. The extent of the interest and assistance is indicated by the fact that the Chairman of the Board, President and two Vice-Presidents of Thompson Products serve on the nine man Ramo-Wooldridge Board of Directors, and give freely of their time to help the executives of the organization make certain that business matters are handled with an adequate level of professional competence. The relations between the two companies have been strengthened still further by the election of three of the officers of Ramo-Wooldridge to the Board of Directors of Thompson Products.

In summary, the ingredients that should provide The Ramo-Wooldridge Corporation with a high probability of remaining a stable ballistic missile program manager are: a field of activity characterized by a demand for competence far exceeding the supply, a staff organized around experienced men with an outstanding record of accomplishment in this field, and an unusual degree of business and financial soundness provided by the strong support of a large and stable company. ★



This illustration shows how the Air Force selects contractors for the long-range missile projects. While all prime contracts have been let long ago, thousands of subcontractors have become involved recently. Subcontracts are still being awarded.



The Ramo-Wooldridge Story

THE ROLE OF The Ramo-Wooldridge Corporation in the Air Force ballistic missile program includes a number of functions under the heading of Systems Engineering and Technical Direction. To be more specific, these functions should be broken down into a group of tasks. One of them is to create an overall research and development plan; a plan that considers what the technical state of the ballistic missile art ought to accomplish to get consistency and a compatible compromise between what science says is possible, and what the military believes it needs.

Next, R-W translates that research and development plan into what one might call an *action plan* that considers what industry can do versus *time*. Selection of the most qualified industry for the myriad of important tasks connected with the ballistic missile program becomes a major consideration. Yet this cannot be done without consideration of the total facility problem.

Ramo-Wooldridge must, in effect, take the initiative for the technical side, and while working very closely with the Government, with the Air Force, and with industry, translate the R&D plan into an accompanying facility plan. All of these things must be done at once, and each feeds back on the other. It's the chicken and the egg problem again. A facility program must go along with an R&D plan and specify, for instance, so many test stands in certain locations near the engineers who are actually going to do the detailed development.

It is necessary for the systems engineer to see that such facilities are provided on schedule. So, the ideal thing then is to create an R&D plan with all its related and supporting annexes, a *facility plan* which considers military requirements, scientific fundamentals, industry know-how and facility acquisition.

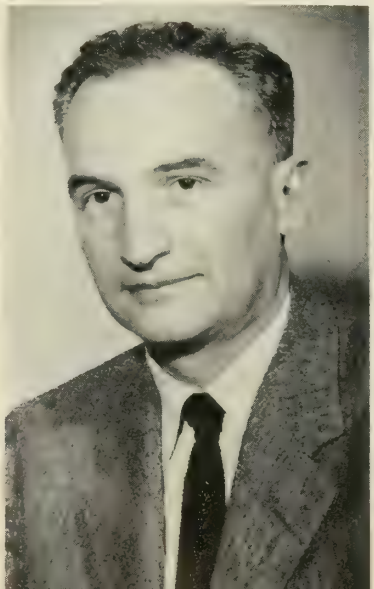
At the same time, Ramo-Wooldridge must consider the backup programs. Where is the technical art closest to the limit of what you can be certain about? Ramo-Wooldridge cannot raise the question of whether something is fundamentally possible. They must create a plan which relates these things from the beginning, in such a way that one can have confidence that the whole project can be brought off. They can only be concerned with *how* to bring it off in the *shortest* time, by the best use of the nation's resources.

Indeed, Ramo-Wooldridge must decide reliabilities at various stages of the program: how far should the Air

Dr. Dean E. Wooldridge, President; Treasurer.



Dr. Simon Ramo, Executive VP, and Sec.



Force go with component testing; and when should the Air Force take on the expensive and more dangerous *systems test?* What will the Air Force *learn* from the initial systems test? Should the Air Force allocate *early testing* for the purpose of getting the team in shape; getting the whole proving ground proven out?

Basically, the Ramo-Wooldridge Corporation conducts research, development, and manufacturing operations in the field of electronic systems for commercial and military applications, and in the field of guided missiles. The company is organized around a central group of scientists, engineers, and administrators who are said to have unusual records of recent accomplishment in these fields.

Both because of the national need and the inclination and experience of the key people, emphasis in the Ramo-Wooldridge Corporation is on the development of products containing *a high degree of scientific and engineering newness.* Every facet of the organization and the operational procedures are designed to fill the special needs of the scientist and engineer.

A certain amount of pioneering spirit is required of those who work together to help develop our big ballistic missiles. All of them enjoy the air of adventure, but most of them, particularly scientists and engineers, like to feel that the odds in favor of eventual success are fairly high. Combined with the probability that early affiliation with a fast-growing organization is likely to lead to a rapid increase in individual responsibility and reward, the result can make for a stimulating and fruitful career. This concept, in particular, applies to the ballistic missile program monitor, the Ramo Wooldridge Corporation.

Major elements in any evaluation of ballistic missile prospects of this young company include (1) the general scope and promise of the field in which the company is engaged, (2) the competence of the organization relative to competition, and (3) the adequacy of the financial backing and business management. With respect to the first two points, there can be no doubt that there is a tremendous national need for greater competence in electronic systems analysis, engineering, and development. The Ramo-Wooldridge Corporation expects to maintain its reputation for competence in this field.

No matter how bright the promise seems, it is still easy for a young company to fail if it is not adequately financed, or if its business management is inept. Both of these contingencies have been guarded against by establishment of strong ties with Thompson Products, Inc., one of the soundest and most highly respected large companies in the United States. Thompson Products, with headquarters in Cleveland, Ohio, has served the automotive and aircraft industries for many years. In addition to an enviable growth record going back for many years, and a volume of business of several hundred million dollars a year, Thompson Products is known for its enlighted management policies, both with respect to personnel relations and operational techniques inside the company, and for its aggressiveness in the development of new fields of interest.

There is no field today that ranks higher, either in importance to the national welfare or in the degree of challenge offered to the scientists and engineers, than that of guided missile development. The strong professional background of its scientists and engineers made it about inevitable that the Ramo-Wooldridge Corporation would take an active part in guided missile development programs. That's why responsibility for the Air Force Intercontinental Ballistic Missile and the Intermediate Range Ballistic Missile Programs—as far as overall systems engineering and technical direction are concerned—was given to the Ramo-Wooldridge Corporation.

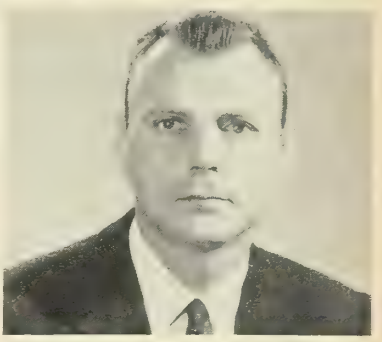
An essential policy established by the Ramo-Wooldridge Corporation is that of maintaining a strong program of supporting research in fields related to the company's major technical areas of activity, but not otherwise directly associated with development projects.

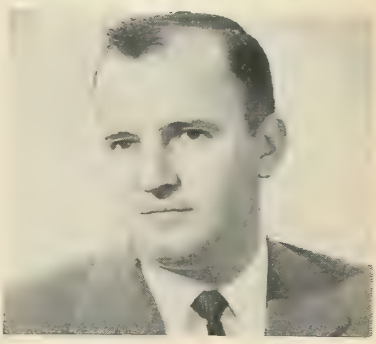
While some supporting research can best be done within the operating divisions that are responsible for development projects, other research work is more appropriately done within separate organizational units. The Aeronautical Research Laboratory and the Electronic Research Laboratory are the divisions in Ramo-Wooldridge that are exclusively devoted to basic or supporting research.

Such research, through the development of new techniques, which are improved and refined goes a long way toward insuring the maintenance of advance scientific and engineering standards throughout the organization. ★











The Ramo-Wooldridge Big Five for Missiles from top to bottom: Dr. Louis G. Dunn, VP and Director of Guided Missile Research Division; Dr. Edward B. Doll, Program Director for the ATLAS, Guided Missile Research Division; William H. Duke, Program Director for the TITAN; Dr. Reuben F. Mettler, Program Director for the THOR; and Adolph K. Thiel, Assistant Program Director for the THOR.

WHO'S GOT WHAT?

The nation's mushrooming ICBM and IRBM missile programs, already approaching the $1 billion mark in allocated Defense spending, have spread in octupus fashion to virtually every segment of U.S. industry. At last count the two programs listed some 17 prime and more than 200 subcontractors.

From the "big five" basic weapons project—Convair's *Atlas* and Martin's *Titan* in the intercontinental category and the Douglas *Thor*, Army Ballistics Missile Agency's *Jupiter* and Lockheed *Polaris* in the intermediate range role—key development contracts for their propulsion, guidance, nose cone structure have dispersed the projects coast to coast.

Only a handful of the key participants have been named. Even fewer have been officially pinpointed to specific projects.

Here's how the big five projects shape up:

Convair's *Atlas*—Air Force has awarded an initial contract valued at $145 million for airframe development, excluding propulsion, guidance and nose cone work. Convair Astronautics Division, organized specifically to handle the *Atlas* and future projects of its type, expects to begin occupying its new $41 million plant at Kearny Mesa near San Diego in June. Eventually, employment in Astronautics Division will reach 6,600.

In *Atlas* propulsion, prime producer is North American's Rocketdyne Division, although Aerojet-General is prominently tabbed as supplier of a second-stage power unit. Rocketdyne, which will supply the *Atlas*' two estimated 100,000 lbs. thrust liquid rocket motors, last month occupied its new $4 million plant at Neosho, Mo. The new midwest location is part of an overall $13.2 million construction project there to gear the division for ballistic missile propulsion work.

Nose cone for the Convair ICBM is being developed by General Electric's Missile & Ordnance Systems Department formed during the past year at Philadelphia. As an index of the pressing task at hand, GE already has subcontracted fabrication of nose cone structural components to Republic Aviation Corp. in a $500,000-plus project.

For guidance, the *Atlas* project looks to General Motors AC Spark Plug Division and another GE department, Heavy Military Electronics, at Syracuse, N.Y. AC's guidance is inertial in variety, that of GE involves radio ground guidance techniques.

Martin's *Titan*—An initial USAF development contract totaling $358 million has reshaped the geographic organization of its prime airframe contractor—The Martin Co. The *Titan* program, centered by Martin in a new $10 million facility in Denver, is already outgrowing the bounds of initial planning.

As a result, a $2 million plant expansion is already in the mill. Present employment of 2,500 is expected to reach 5,000 next year.

Titan propulsion is assigned to Aerojet-General at Azusa, Calif. Prime contractor for nose cone development is Avco Manufacturing Corp. at Lawrence, Mass. with Lockheed Aircraft Corp.'s Missile Systems Division lending research support to both the *Atlas* and *Titan* nose cone R&D effort via its X-17 research project.

In *Titan* guidance, American Bosch Arma Corp. of Garden City, N.Y. is spearheading inertial guidance development and Bell Telephone Laboratories/Western Electric Co. at Whippany, N.J. is working on radio guidance.

Douglas *Thor*—The Air Force's IRBM entry, already in the test stage, is supported by an initial development and evaluation contract totaling $67.5 million. In addition to AF contracts of $1,305,500 and $2,340,083, Douglas is investing $3 million in facilities for *Thor* development and testing in the Sacramento, Calif. area. Contracts amounting to $2 million already have been let for construction on a 1,700 acre site there.

Propulsion for the *Thor* is being handled by NAA's Rocketdyne Division, guidance by AC and Bell Laboratories, all repeaters from the ICBM program.

In all three USAF ballistic missile projects, two other firms hold key contracts. The specialized task of developing warheads belongs to Sandia Corp., Western Electric subsidiary at Albuquerque, N.M. Engineering responsibility and technical direction for all AF ballistic missiles is vested in Ramo-Wooldridge Corp.

Jupiter—Army's IRBM under technical cognizance of Army Ballistic Missile Agency at its Redstone Arsenal has airframe development assigned to Chrysler. Total funds amount to an estimated $140 million. Prime production of propulsion has been awarded to North American for a 135,000 lb. thrust liquid rocket, although Aerojet-General is known to have developed what it calls the "largest solid rocket ever used" for the *Jupiter* IRBM.

Polaris—newest of the IRBMs, resulting from Navy split with the Army in intermediate range ballistic missile development, has airframe development at Lockheed Missile Systems Division. Also in this project are Aerojet-General Corp., presumably with the large solid rocket it developed for the *Jupiter*, General Electric and Massachusetts Institute of Technology, both of the latter in guidance development.

In addition to these prime development assignments, American Machine & Foundry Co.'s Turbo Division is developing auxiliary power units for unnamed missiles.

Two missile firms, Associated Products Corp. of Pomona, Calif. and Hallamore Electronics of Anaheim, Calif. have opened Denver facilities as subcontractors to Martin in the *Titan* program. Hallamore is also subcontractor to Convair in the *Atlas* project.

Baldwin-Lima-Hamilton Corp. holds subcontracts from Martin for *Titan* test stands and, in turn, has contracted with Beckman Instruments, Inc. to supply specialized computers. Douglas also has ordered Beckman data processing equipment to speed *Thor* research.

Burroughs Corp. holds contracts for data processing equipment in the ground control equipment for the IRBM/ICBM program. Fruehauf Trailer Co., Los Angeles plant, is building special *Thor* truck-trailers under a $1.5 million subcontract from Douglas.

But these are only a few of the 200 subcontractors active to date in the ICBM and IRBM in the programs. The roster of the unnamed, obviously even more impressive by its numbers alone, remains to unfold.

SPACE POWER

When US Air Force becomes US Space Force

by Dr. Donald Cox
The Martin Company

AT SOME historic moment between July, 1957, and December, 1958, a great, three-stage rocket will roar upward from the sands of Patrick Air Force Base in Florida. Shedding its expendable parts as it rises, the rocket finally will reach the fringe of outer space. Here, 200 miles away from earth, it will release a gold-plated sphere about the size of a basketball. This object named *Vanguard* will be the first of many artificial satellites.

The *Vanguard,* propelled by its own momentum, will follow an elliptical orbit at an initial speed of 18,000 mph. For a while, the speed will counterbalance the earth's gravitational pull, and the satellite will complete one revolution about once every 90 minutes. Eventually, as momentum slows the satellite the *Vanguard* will sink into the denser atmosphere nearer earth until it is consumed by friction.

Briefly, the disintegrating satellite may resemble a meteor to earthbound observers far below. But by then, instruments rested in the *Vanguard's* shell will have transmitted vital data to the scientists of more than forty nations, whom we are encouraging to track the satellite. In time, these men and women who represent participating countries in the 1958 International Geophysical Year, will translate the space messages into knowledge that may help mankind make use of infinity for commerce or for war.

Dr. Hagen, the Chief Scientist in charge of the *Vanguard* project, stated on a recent TV interview that he hoped the first satellite would: 1. help us find the true shape of the earth, 2. discover



Above the troposphere, which ends at 13,000 feet, man's stairway from up to out begins. Now the technologically more advanced nations are vying for top-dog position in the stratosphere. Within a decade unmanned vehicles will carry this race into interplanetary space.

The Legal Aspects

One of the interesting developments at the American Rocket Society Spring Meeting in Washington earlier this month was the Space Sociology Seminar in the afternoon session on Thursday, April 4, which was presided over by Dr. Theodore von Karman, Director of the Advisory Group for Aeronautical Research and Development of the North Atlantic Treaty Organization.

Andrew G. Haley, General Counsel of the American Rocket Society, read a paper on "Space Law and Metalaw—Jurisdiction Defined." In his talk Haley pointed out that he had been criticized by Mr. A. E. Slater in a recent issue of the Journal of the British Interplanetary Society for not adequately defining the *jurisdiction* of space law. Haley stated that after making a careful study of the writings of authorities on the subject, he determined to seek out a definition of space jurisdiction based upon principles derived from scientific considerations.

"At about this point in my quest," Haley said, "I received a telephone call from Dr. Theodore von Karman inviting me to spend the evening with him. He had just arrived in Washington from Paris.

"By coincidence, this summons started a chain of memories. One of these was in the autumn of 1942, when 'the Boss,' as I was privileged to call the good Doctor, advised me confidentially that the University of California at Los Angeles was to award him an honorary degree and would I be kind enough to attend the presentation. A short while later, at the general convocation, the Provost of the University of California at Los Angeles, awarded the Boss with the degree of Doctor of Laws! On the way back to Pasadena, we had a great deal of fun speculating on the future career of Attorney von Karman.

"So a few weeks ago as I pondered on space law jurisdiction, and my forthcoming visit with the Boss, my mind went back fifteen years to this incident and I decided, as of old, to discuss my problem with the good Doctor. As always, Dr. von Karman formulated a precise answer as to the jurisdiction of space law. During the evening he told me that he had delivered a paper last year at a luncheon at the University of California, Berkeley, entitled 'Aerodynamic Heating—the Temperature Barrier in Aeronautics' and in that paper he had occasion to use a diagram made by Masson and Gazley of the Rand Corporation showing the possible ranges for continuous flight in the velocity-altitude coordinate system. Later on, he sent me a copy of his paper which contains the Masson and Gazley diagram. He said that this diagram, although designed to show the variation of velocity versus altitude for various values of dynamic pressure and equilibrium pressure, could readily be used to show the regimes of atmospheric and extra atmospheric flight and to depict the jurisdictional boundary lines thereof.

"I have re-done the Masson and Gazley diagram to indicate a line showing orbital velocity and another line showing the boundary of the Keppler regime [escape velocity].

"Conditions for accomplishing aerial flight, that is, circle at constant altitude, is weight = aerodynamic lift plus centrifugal force. The aerodynamic weight decreases with altitude because of the decreasing density of the air and in order to maintain continued flight beyond a certain point, centrifugal force must take over. Consider the flight of Captain Ivan C. Kincheloe, in which he took the X2 rocket plane to 126,000 feet altitude. His flight was strictly an aeronautical adventure and did not partake of space flight. At M = 3 aerodynamic lift carries 98% of the weight and only 2% is centrifugal force, or 'Kepler force.' However, it will be noted that in the corridor of continuous flight when an object reaches *approximately 275,000 feet* and is *traveling at 35,000 feet per second,* the Kepler force takes over and aerodynamic lift is gone.

"I have reproduced the Masson and Gazley right side curve—so-called temperature carrier, or heat barrier, simply to show the present state of the art, and thus to delimit the corridor of continuous flight. This line has nothing to do with the jurisdictional question as improved techniques in cooling and discovery of heat resisting materials will undoubtedly change this curve.

Thus, the jurisdiction question is settled from a scientific angle."

the true nature of the earth's atmosphere, and 3. find out about the sun's ultra-violet and infra-red radiation. Outerspace travel may take a few years, but the time for contemplation has already arrived.

Men must be mentally and emotionally prepared for the revolutionary experiences now in prospect, including an understanding of some of the political, military, economic and social implications involved.

We have discovered a new frontier with problems similar to those of western America in the latter 19th Century. Like the settlers in the old West who lost their claims if they did not protect them, so we have the challenge of exerting our claims over space, and keeping it out of the hands of enemy "rustlers."

"Space" and "Spacepower"

The atmospheric frontier or interplanetary space begins between 400 and 2000 miles up. This is known technically as the exosphere.

Space vehicles, when they are perfected will be beyond the earth's gravitational pull and beyond the sound barrier, about 450,000 feet up.

When man breaks through the envelope surrounding the earth, he will, from a military standpoint not only have to be on the lookout for possible "Martians" in space but more immediately will have to assure himself that his nation's air space is controlled and adequately protected.

Spacepower is dependent on airpower control in the atmosphere below the space frontier. They should never be thought of separately.

Due to the limited altitudes of present-day air vehicles, powerful military nations in peacetime can control their air space as a privileged sanctuary under the rules of international law. The advent of space satellites, guided missiles, and space ships whether atomic, chemical, or rocket powered will lead to a revolution in national air sovereignty.

From the launching of the first earth satellite, a new era will have begun, i.e., the ending of national control over air space. For space is truly international, no matter how one cuts it. Any point at 200, 300, or 1000 miles up probably dominates parts or all of two or more nations on the face of the earth simultaneously, and this makes for complications in the problems of international relations regarding former aerial domains.

The elimination of national air and space boundaries would mean a 'fait accompli' victory for President

Eisenhower's open sky policy, whether other nations accept this fact by signatures on diplomatic documents giving permission, or not. For once the first satellite is launched, it will only be a matter of time before powerful aerial cameras are perfected to transmit pictures of enemy territory and installations back to earth. Constant inspection of every country, city, and body of water can be maintained by such satellites, and could set our warning bells ringing against any future Pearl Harbor buildup.

In a June 1956 issue of *Life* magazine, Charles J. V. Murphy wrote ". . . an effective space platform, equipped with cameras and telemetering devices, would provide either the Russians or ourselves with a means of continuous surveillance of each other's industrial and missile deployments—crucial intelligence in a period when nations will have power to obliterate their enemies."

The higher the altitude, the more earth's surface will be dominated by any one space vehicle—former safety zones on earth will be all but eliminated. Still to be determined is the altitude at which a nation's air sovereignty ends and "open" space begins.

Another thing that will end national boundaries, is the necessity for dispersed, international ground control nets to guarantee that space vehicles reach the proper altitudes for operation. While flying over foreign territory, a space vehicle must often rely on ground control stations in that country to gain the proper altitude.

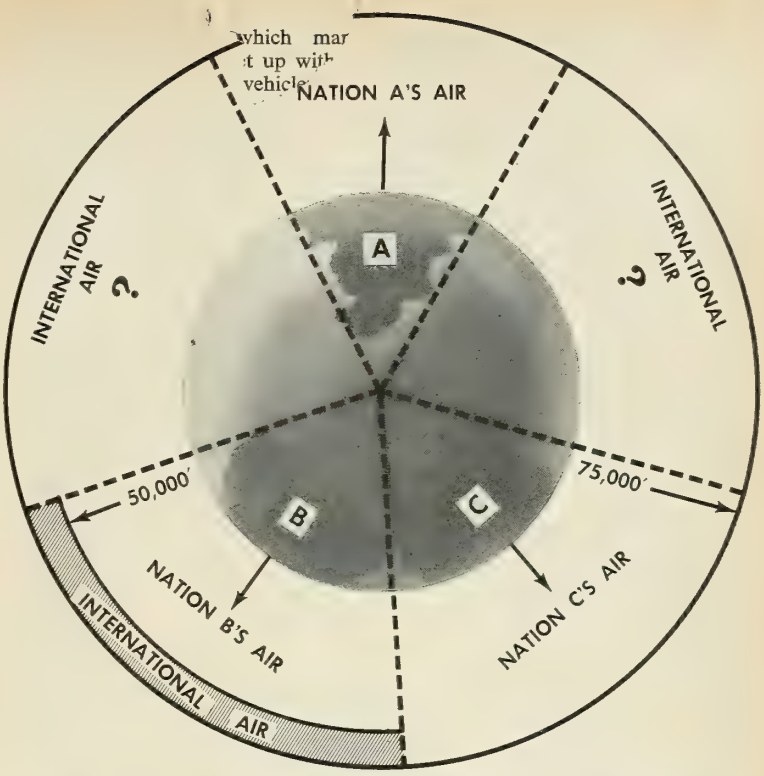
Thus, a few of the larger territorial nations could hamper other nations' attempts to perform high altitude flying if they try to retain their "sovereign air space."

The s e c o n d obvious c h a n g e brought by the conquest of space is: The limitations of any single nation's spacepower will depend on the speed, altitude, and staying ability of their space vehicles.

These three factors will become a primary deterrent of future conflict, as long as peace-loving nations can keep their vehicles out the farthest and up the longest without refueling.

These three factors alone, however, will not guarantee that nation A will always be able to exert its will of space control over nation B and C.

The interrelation of each of these factors is significant because you cannot have one without the other. To obtain the highest altitudes, great speed is necessary and inability to attain the higher altitudes prevents great speed. The addition of "staying ability" guarantees that the duration, speed, and



International law now reads that a nation holds sovereignty over all above and below the surface of the earth under its control, plus a pre-stated distance out over the water. This is a simple concept that has worked reasonably well for thousands of years. However, it cannot be extended indefinitely outward to the infinite reaches of galactic space. It probably won't even work 500 miles up. The top illustration shows how vertical aerial boundaries become radial when vast altitudes are considered. Both diagrams emphasize the importance of maintaining technological superiority in order to get manned vehicles to the highest altitude.

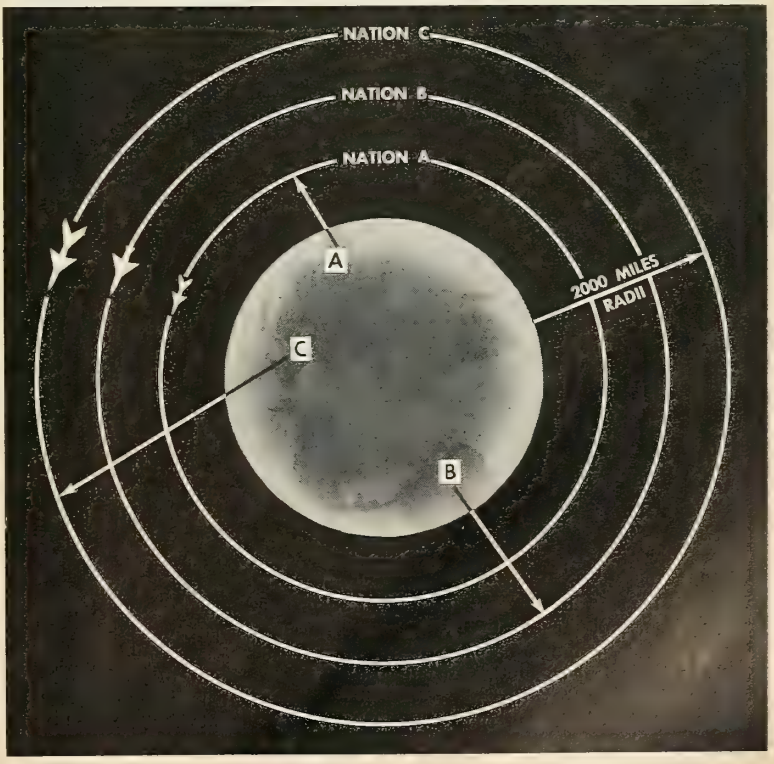




Diagram shows how a satellite will be able to dominate more than one nation at a time. The higher the orbit of the satellite, the greater earth area will come under its surveillance. Additionally, either manned or unmanned space satellites at the higher altitude would be in an advantageous position to take action against those below. In the one case missile assault would be aided by gravity; in the other, it would be hindered.

height of any vehicle will remain constant—otherwise, it will fall back to earth and lose speed as it re-enters the denser atmosphere.

Control of Space

Current U.S. Air Force doctrine is based on control of the air. Since the degree of control by our (and our allied) air forces is relative at any given moment, several factors become apparent when we extend this theory to "control of space."

The higher man ascends through the fringes of the atmosphere and into the frontiers of outer space, the more difficult it will be for him to control absolutely the significant portions of the air ocean and space between him and earth. This assumption, when extended to its logical conclusion, would lead one to believe that to retain comparative control of air and space, nations would have to numerically or qualitatively increase their air and space vehicles in direct proportion to the additional miles of altitude. They would have to provide for complete serveillance and countermeasures.

The characteristic of vertical employment is one of the advantages of airpower and space power over land and water-borne war weapons. The extended application of this characteristic to higher altitudes multiplies the problem of control over the dominions of outer space and the earth's atmosphere. The nation that masters speed and altitude coupled with staying power will be in a better position to dominate the world even though the problems and areas of control are more difficult in scope.

Such a nation could also better guarantee freedom of flight although fixing set frontiers in the layers and spheres of the atmosphere and space would be difficult to determine.

The Higher Out, the Easier Control

To offset the disadvantage of higher altitude—more space to control in all directions—is the advantage of being on top. It's like standing on the summit of Mt. Everest, with all the rest of the known earth's crust below.

So it is true of altitude in space. Knowledge that other nations have not ascended as high as you, gives the top nation a feeling of security that no others can have, a command control of the earth. On this point Professors Stefan Possony and Leslie Rosensweig in a significant article entitled "The Geography of the Air," published in May 1955 in the *Annals of the American Academy of Political and Social Science* wrote:

". . . As man reaches upward to the outer atmosphere new political problems arise, the nature of which we are not yet able to grasp. Heretofore, the relations between nations took place on what in practice was a plane. During the time of low altitude flying, the relations between nations and military forces were determined by the geometry of a spheroid's curved surface. This period of close-to-the-ground flying was, and still is characterized by 'the polar concept.'

"Henceforth, international relations will be geared to the more difficult geometry of a large spheroid enveloping as its core a smaller and impenetrable spheroid; the earth. But even more confusing, the radius of the outer spheroid—symbolizing the aeropause or the altitude which man has attained at any given time—is expanding.

"The most advanced nation technologically will operate within the highest aeropause, while the spheroid circumscribing the aerial capabilities of the more backward nations will have shorter radii.

Hence in the future, the geography of power will be described by several enveloping spheroids of different sizes. It will be a far cry from the geography of the battles of Yorktown and Bastogne, or even from the aerial battles of World War II. Truly a new *Weltbild* is emerging."

Technically, as Dr. Wernher Von Braun pointed out you can bomb a certain spot more accurately from 2,000 miles out in space than 5 miles up in the air from the target—since you would have control of the bomb all the way to the target in the former situation, but not in the latter.

Sustained Flight Vital

Those nations which can successfully launch and maintain the greatest number of manned and unmanned satellites in space, will have more op-

portunities to exert their will in the air and space medium.

This fact makes the perfection of long-range, nuclear-powered air vehicles a significant step forward in maintaining air and space superiority. The prolongation of flight around the earth by manned nuclear air vehicles will help make possible a continuing space sentinel system, not possible before.

The perfection of nuclear powered air and space vehicles will make control more feasible as a nation's nuclear power capabality increases. Such sustaining ability at the highest altitude and with the greatest speed will enable the leading nation to achieve five fundamental military aims: (1) persuasion, (2) neutralization, (3) denial, (4) destruction, and (5) capture. Applied spacepower would make the first three particularly effective. The last two—destruction and capture—need never be carried out if the first three are applied judiciously by the space power nation exerting them.

Space Counter Measures

Nuclear powered space vehicles would have to be knocked out somewhere in space rather than at their launch sites, unlike the current theory of stopping aggression on the ground before launching. As this type of vehicle is not a land-oriented vehicle, there is only one place it can be destroyed, and that is in its natural habitat—air space. To concentrate on finding an enemy's space launching sites on land would be well nigh impossible after hostilities had started unless one was thinking of a preventative war. Even then, the main threat which would already be air and space borne, could not be overlooked.

As more potentially destructive vehicles will be in flight rather than at their launching sites at the outbreak of hostilities, an added burden is placed on the defender nation. In some respects it would be an almost impossible task for a nation to defend itself against a multitude of enemy "flying saucers" constantly whirling around the earth in their space orbits.

With the *Vanguard* test firing program already under way, perfection of the ICBM in sight and with serious plans to go ahead with hypersonic boost glide vehicles, the problems of space flight and control are not somewhere in the eventual future. They will first arise during the next decade, develop to full proportions during the life of the current generation.

These combat space vehicles pose a defense problem which defies the limits of man's imagination. This also holds for the planetary objects, cosmic particles and meteors which man-made air vehicles will meet up with in space. Either the space vehicles will have to ward off such objects or suffer the consequences.

In one sense, as we stand on the threshold of space, we find ourselves in a similar state as the hunter on a safari at the edge of a dense jungle. The size and number of his weapons, will determine how far into the jungle he can penetrate with hopes of returning safely. He knows that he can't go too far in if he doesn't have the implements to fight his way out alive. Such is the military problem facing the Western World as it ventures into the space frontier.

The Ultimate Challenge

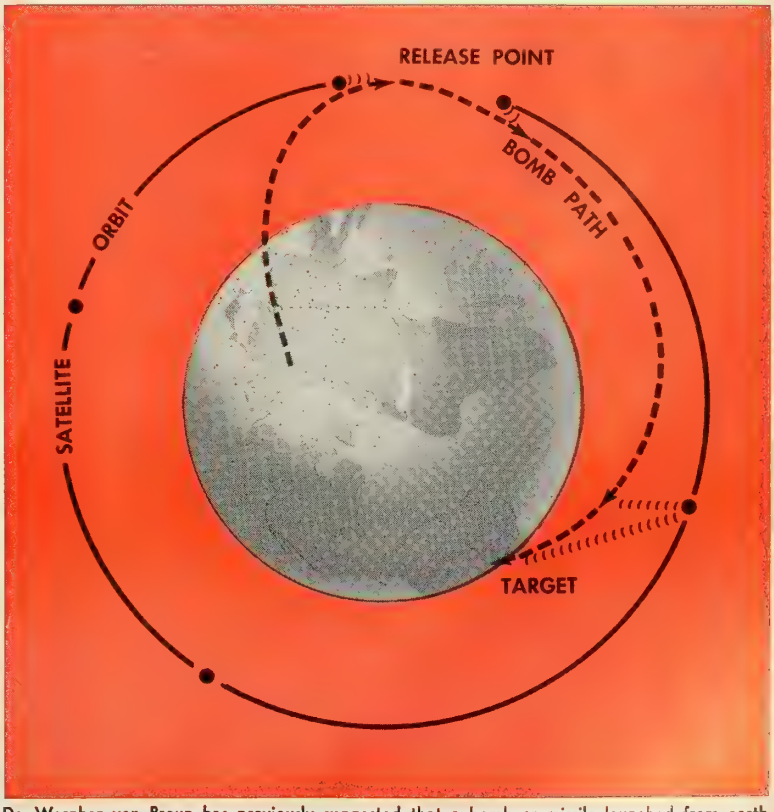
The public relations department of the Glenn L. Martin Co., prime contractor for the first satellite launching vehicle *Vanguard* in speaking of its forthcoming endeavor, remarked:

"Thus one day soon, in the hour before sunrise, as men the world over train their binoculars upon a brilliant point of light in the sky, they may well reflect upon the universality of man's faith in the infinite future of man."

This "reflection" is needed now to help coin a valid space doctrine to keep the myriad space satellites, rocket ships, intercontinental missiles and space stations from getting out of control. Such a doctrine is necessary to provide a secure foundation for "spacepower" in the future, and to aid us in understanding the technologically complex struggle for control of the earth's air and space beyond.

As the air and space revolution gathers momentum, we are challenged as never before to face up to the tasks of our new international spacepower and learn to cope with its unchanging nature. The hopes and fears of our civilization are tied to the necessity of such an understanding now.

Space flight will help to modify the world—rather than divide it. True space flight to the planets and the stars will only come after the world is united and the threat of war removed. This is the ultimate challenge to mankind, so that spacepower can be used for predominately peaceful purposes. ★



Dr. Wernher von Braun has previously suggested that a bomb or missile launched from earth could be picked up by a manned satellite, carried half way around the earth, released and guided down to its target—another concept of importance when considering space-power.

CONTACTS FOR CONTRACTS

If you want a contract with the Air Force Office of Scientific Research, first familiarize yourself with the basic thinking of the men who run it.

AFOSR is one of 12 centers of the Air Research and Development Command, with headquarters in Washington, at 14th Street and Constitution Avenue Northwest. It has been given the mission of conducting the *exploratory* research program for the U.S. Air Force. The word "exploratory" is the key to its aims and objectives.

Admittedly, exploratory research, as defined by AFOSR, has a relatively low success probability, but a very high pay-off if successful.

The table of organization of AFOSR shows how well organized is this branch of the Air Force. It includes nine divisions representing basic scientific disciplines; behavioral sciences, mechanics; aero-medicine, combustion dynamics, physics, chemistry, solid state sciences, mathematics and nuclear physics.

These divisions are grouped under four "directorates." These are the Directorate of Bio-Sciences, the Directorate of Aeronautical Sciences, the Directorate of Physical Sciences and the Directorate of Material Sciences.

There are also the Directorates of Advanced Studies, of Research Information and of Procurement.

In establishing contact with AFOSR, a prospective research contractor should address his original letter of inquiry to the Commander, Brig. Gen. Hollingworth F. Gregory. A contractor's contacts with the organization will generally be with the division covering the scientific discipline, which handles the technical aspects of contracts, and the Directorate of Procurement, which deals with the financial aspects of negotiating, renewing the contract.

A primary proposal should state the field of investigation, the specific objectives, previous work done, the method of investigation and the estimated total cost. It should also list the names of the principal investigators and what percentage of their time would be devoted to the project.

The preliminary proposal is evaluated by the appropriate technical division and its consultants. If it is favorably received, the investigator should be prepared to submit a more elaborate and detailed proposal, for which instructions will be furnished.

The Armed Services Technical Information Agency in Dayton, Ohio, provides a service for the exchange of scientific and technical information to prime contractors of the military departments and, under certain circumstances, their subcontractors.

But for those contractors, or prospective contractors, who want a detailed statement of the research interests of AFOSR in the fields it covers, a 16-page booklet on the subject can be obtained by writing to AFOSR.

1. **Directorate of Aeronautical Sciences.** The Mechanics Division of DAS is interested in aerodynamics, aerostructures, and both aerodynamic and structural problems at high speeds. Aim of its aerodynamics program is to assure the continued growth of this science and to evaluate new knowledge.

Principle subfields of interest are: subsonic flow (Mach 0.8), hypersonic flow (Mach 0.8-1.1), supersonic flow (Mach 1-5), hypersonic flow (Mach 5), internal flows, aerothermodynamics, rarefied gas dynamics, turbulence and facilities, instrumentation and techniques for model and full-scale testing.

Fluid mechanics is another subject of considerable interest to the Mechanics Division. At hypersonic speeds, not only is a vehicle—whether an ICBM or an earth satellite—heated to extreme temperatures, but even the air around it undergoes changes in state and composition. These changes, it is pointed out, have marked effects on aerodynamic and structural design considerations. Research interests in this area encompass the determination of the fluid dynamics and the chemicophysical laws governing vibration, dissociation, recombination and ionization of gases and their effects on the aircraft structure.

The Combustion Dynamics Division of the DAS is primarily concerned with the physical and chemical processes by which energy is provided for the propulsion of aircraft. This includes the problem of energy storage, which requires thorough basic knowledge of the various forms of potential energy: nuclear, atomic and molecular binding energies, as well as gravitational and electromagnetic potential energy.

2. **Directorate of Bio-Sciences.** The Aeromedical Division of this directorate is interested in biological and physiological operational and environmental stresses. The object is to provide protection against various adverse conditions and to improve performance under those conditions.

The Behavioral Sciences Division of this directorate initiates both basic and exploratory research that will contribute to the better understanding of human behavior. This division encourages "interdisciplinary" research in the psychological, anthropological, sociological and psychiatric disciplines, utilizing existing research personnel and facilities.

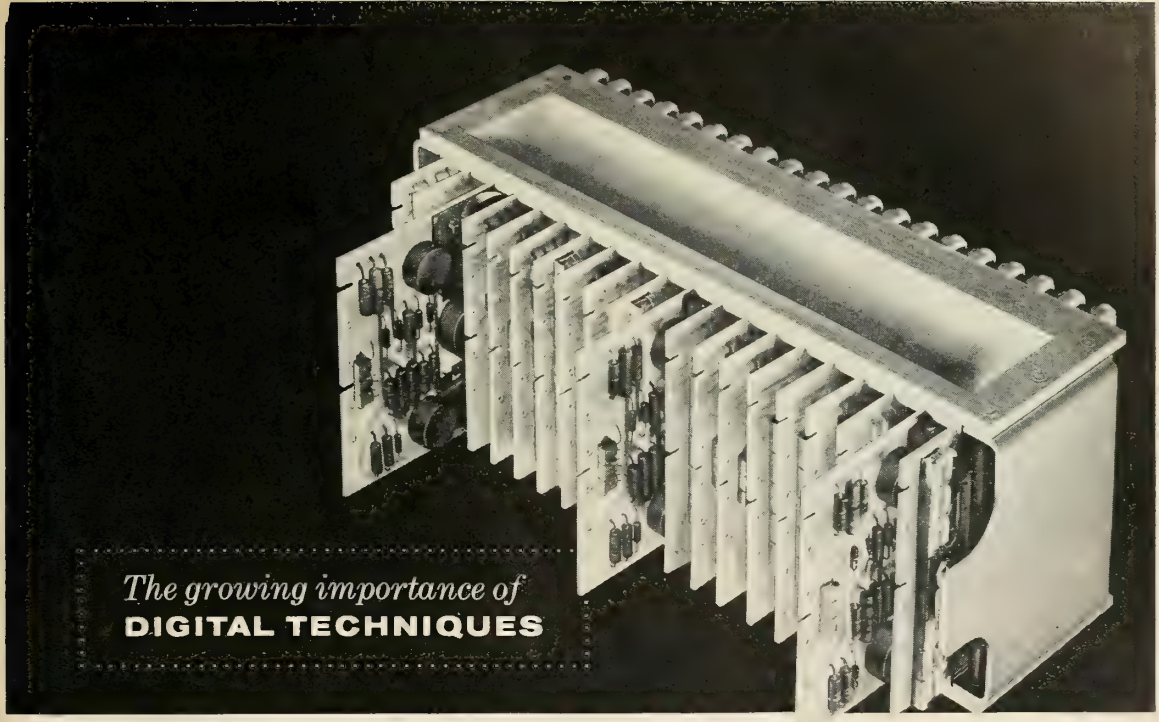
3. **The Directorate of Physical Sciences.** The Physics Division is concerned with the study of atoms and molecules as the basis for interpreting many of the properties of matter. It is also interested in the properties of electro-magnetic radiation which are used for communication or detection.

In the field of atomic and molecular physics, infrared and ultraviolet radiation, thermodynamics and statistical mechanics, molecular structure, acoustics and hypervelocity particles are all of particular importance to AFOSR.

The Nuclear Physics Division of this directorate is concerned not only with the development of nuclear power and its related problems but also provides information to improve the properties of materials. For example, new applications appear possible in the use of nuclear resonance which would aid in the chemical-trace analysis of certain types of impurities. The division also is interested in nuclear structure and reactions, cosmic rays, fundamental particles and nuclear instrumentation.

4. **The Directorate of Material Sciences.** The Chemistry Division of this directorate is interested in many subjects, including: the theory of chemical bonding, chemical reactivity, new compounds, high-temperature materials, catalysis, surface chemistry, photo chemistry, nonequilibrium kinetics, nuclear chemistry and high-temperature reactions.

The Solid State Sciences Division of this directorate has established its ultimate aims as follows: (1) to make better use of desirable physical properties of solids for Air Force use and (2) to discover new phenomena that might lead to novel applications.



As recently as ten years ago it was just becoming evident that digital techniques in electronics were destined to create a new and rapidly growing field. Today, incorporated in electronic computers and other equipment, they constitute one of the most significant developments in scientific computation, in electronic data processing for business and industry, and in electronic control systems for the military. In the near future they are expected to become a major new factor in industrial process control systems.

The digital computer for scientific computation is becoming commonplace in research and development laboratories. Such machines range from small specialized units costing a few thousand dollars, to large general purpose computers costing over a million dollars. One of these large computers is a part of the Ramo-Wooldridge Computing Center, and a second such unit will be installed the latter part of this year. The digital computer has not only lightened the computation load for scientists and engineers, but has made possible many calculations which previously were impracticable. Such computers have played a major role in the modern systems engineering approach to complex problems.

Electronic data processing for business and industry is now well under way, based on earlier developments in electronic computers. Data processors have much in common with computers, including the utilization of digital techniques. In this field, teams of Ramo-Wooldridge specialists are providing consulting services to a variety of clients on the application of data processing equipment to their problems.

The use of digital techniques in military control systems is an accomplished fact. Modern interceptor aircraft, for example, use digital fire control systems. A number of Ramo-Wooldridge scientists and engineers have pioneered in this field, and the photograph above shows a part of an R-W-developed airborne digital computer.

These, then, are some of the aspects of the rapid growth which is taking place in the field of digital techniques. Scientists and engineers with experience in this field are invited to explore openings at The Ramo-Wooldridge Corporation in:

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Airborne Electronic and Control Systems
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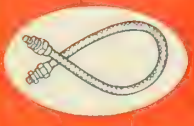
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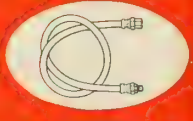
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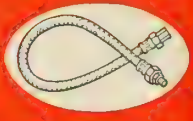
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The Rocketdyne Boom:

Engines for USAF's Long-Range Missiles

WHILE SECURITY restrictions prevent a presentation of rocket engine facts in terms of thrust, specific propellant combinations and production figures, it is generally conceded that the rocket engine industry has made tremendous strides in recent years, permitting U.S. long range missile development to progress at an unprecedented and confident pace.

Some hints of this progress have been disclosed:

The range of the German V-2 propulsion system could be increased by from 50 to 100 per cent if we were to build a missile today of the same size, weight and payload.

The ultimate performance of propelled rocket engines liquid is governed only by the rate at which propellants can be pumped into the combustion chamber and burned efficiently.

In the field of fuels, research scientists see a 50 per cent increase in power potential before they reach an energy barrier. Beside the standard V-2 alcohol and liquid oxygen propellant, two other potent combinations of fuel and oxidizer have been brought into standard use today: nitric acid and aniline; and gasoline and oxygen.

Other promising indications: development of 12-inch-diameter gas generators that produce in the order of 10,000 isentropic horsepower in hot gases to drive turbopumps and successfull operation of the 50,000-lb. liquid propellant rocket engines in 120 test sled runs, indicating that new reliability standards are being achieved in the use of liquid fuel rocket engines.

These and other advances may be interpreted as significant indications that long range missile propulsion, through the use of high-thrust liquid propellant rocket engines, has caused a major technological break-through in this decade.

Starting with the Geman V-2 scientists and hardware following World War II, U.S. long range rocket propulsion technology progressed from the Air Force-North American *Navaho* propulsion system through the Army-Chrysler *Redstone* and into the realm of the Air Force's Ballistic Missiles Program in the intermediate and intercontinental range brackets (*Atlas, Titan, Thor*). Recent reports have placed the Army-Chrysler *Jupiter* alongside the *Thor* in the 1500-mile class.

Today's long range missile propulsion systems are the direct result of early confidence in the future of rocketry expressed by U.S. industry,

Long range propulsion systems require new—and expensive—facilities and techniques. Here, at Rocketdyne's Propulsion Field Laboratory in California, afterburners ignite gasses used in test of rocket engine gas generator. Note desolate, unpopulated area.





Rocket test rises stand from Missouri countryside as Rocketdyne pushes construction at its 200-acre test complex at Neosha. A major part of the ICBM program, this plant will test and construct high thrust liquid propellant engines.

and 12 years of engineering achievement in a field new to technology.

A leader in this field is Rocketdyne, a division of North American Aviation, Inc., now supplying high thrust rocket engines for virtually all of the long range missile programs.

The Canoga Park, California firm today employs more than 10,000 persons almost exclusively in the development and production of long range liquid propellant rocket engines for the Air Force's *Atlas* and *Thor* programs, the Army's *Redstone*, and *Navaho*.

Company officials were optimistic over the future of high thrust rocket propulsion following World War II, when NAA was asked by the Air Force to undertake development of the *Navaho* long-range guided missile.

Starting with a nucleus of five research engineers in 1946, NAA President J. L. Atwood and others began the task of recruiting a scientific staff for the job, expecting that missile development would be the logical extension of the airframe business.

When progress had been made in their studies of high-speed aerodynamics, heat transfer and related subjects, the Air Force accepted an NAA proposal for institution of a long-range research and development program.

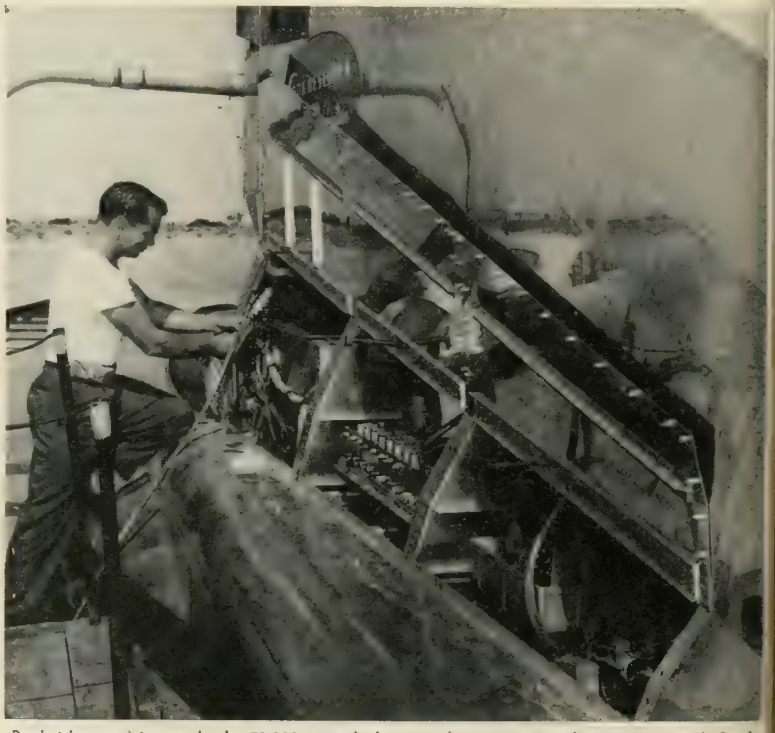
The late 1940's saw the establishment of a Propulsion Field Laboratory in the Santa Susana Mountains near Los Angeles, on 600 acres of isolated mountainside. Thus was born U. W. technology in the field of large, liquid propellant rocket propulsion.

After only eleven years in rocket propulsion Rocketdyne has brought the issue out of the doubtful stage and into the hands of assembly line production experts, who today are turning out rocket engines in much the same manner as fine quality automobile engines. Highlighting the division's manufacturing effort will be the full scale operation, this August, of the nation's first plant devoted exclusively to the production of long range rocket propulsion systems in Neosho, Mo. The $13 million Air Force-owned plant, including a 200-acre acceptance testing complex, is expected to employ 1,000 persons by late this year.

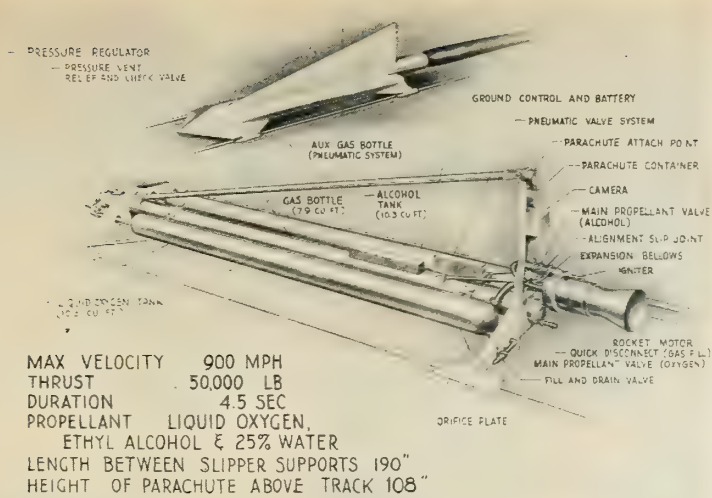
While early confidence in the future of long range rocket propulsion is largely responsible for Rocketdyne's success, company officials cited these factors as helping to close the area of doubt over the past 12 years:

A top level team of engineer-managers has been brought into the picture. Led by General Manager Samuel K. Hoffman, 55, with 32 years experience in aeronautical engineering including a professorship at Pennsylvania State; and Assistant General Manager Charles W. Guy, 40, who has been active in aircraft engineering and administrative posts since his graduation from MIT in 1939. He largely shoulders administrative jobs to free Hoffman for engineering decisions.

Other key men in the Rocketdyne management picture: Chief Engineer Thomas F. Dixon, 41, 10 years in long range propulsion engineering with NAA; Propulsion Field Laboratory Manager James A. Broadston, 48, 21 years with NAA and probably the Na-



Rocketdyne engineer checks 50,000 pound thrust rocket engine used in 5000 pound Cook parachute sled. Capable of reaching 900 mph in 4.2 seconds, this unit has successfully completed 120 test runs and boasts a largely trouble-free record of performance.



This schematic drawing shows operative details of the Cook sled propulsion system. In one tenth of a second from firing sled is accelerating at 10 G's, its engine having reached 80% of full thrust. Water wall that stops it gives 65,000 pounds resistance.

tion's top specialist on large rocket engine test; Preliminary Design Chief George P. Sutton, 37, author of "Rocket Propulsion Elements," vice president of the American Rocket Society; Neosho Plant Manager Joseph P. McNamara, 46, who was assistant to the division manager at NAA's Kansas City plant during World War II and has 22 years of diversified engineering experience; Research Chief John Tormey, 38, with 11 years' research experience with NAA, who directs efforts of 140 Rocketdyne researchers and is a top authority of high energy rocket propellants; Factory Manager Ross Clark, 45, who progressed from the position of assembly mechanic with Northrop Aircraft through 24 years of manufacturing experience to lead Rocketdyne's production effort.

Production experience gained during World War II on the F-51, B-25 and other airplanes has enabled Rocketdyne managers to recruit, train and utilize technical talent on a large scale. This explains why the organization has been able to expand from 4500 to 10,000 people within one year with a minimum of confusion. High-geared indoctrination programs, classroom training, quick dissemination of fresh information all figure in this program.

More than 4,100 persons are engaged in some phase of Rocketdyne's engineering effort today. Emphasis has been placed on attracting and training combination engineers. Test engineers, for instance, help design test stands, then assume responsibility for their operation. This requires civil, mechanical and electrical engineering know-how.

Development of hardware is based on solid, factual experience. Extensions of technology are founded on lessons already learned rather than unproven hypotheses. The result is a steady progression toward objectives.

From the standpoint of basic engineering design, there has been no sharp distinction from one stage to the next, with the exception of several components, whose redesign was necessary. Generally speaking, the components, controls, inter-connects and operating sequences were improved on the basis of test experience. The development of thrust chambers, turbopumps, propellant feed systems, feed system controls, gas generators and gas generator controls followed a logical sequence of improvement.

When necessary to meet tight military schedules, Rocketdyne has set up double shifts in production and testing activities. Maj. Gen. B. A. Schriever, commander of Western Development Division, ARDC, has cited Rocketdyne's double shift testing program in keeping production and delivery of engines on schedule.

Since completion of Rocketdyne's 316,000 square-foot Main Plant building in Canoga Park, California, in November, 1955, expansion has been rapid. In addition to the Neosho plant, operations have required addition of a 50,000 square-foot engineering annex and an 88,000 square-foot material building and six other supporting facilities within the last year.

While development of the art at Rocketdyne has been sober and well planned, engineers have not hesitated to follow strange pathways in their quest for fresh knowledge. As a result, their explorations in fluid mechanics, supersonic aerodynamics, thermodynamics, electronics and other fields, performance and reliability standards thought impossible 10 years ago have been achieved.

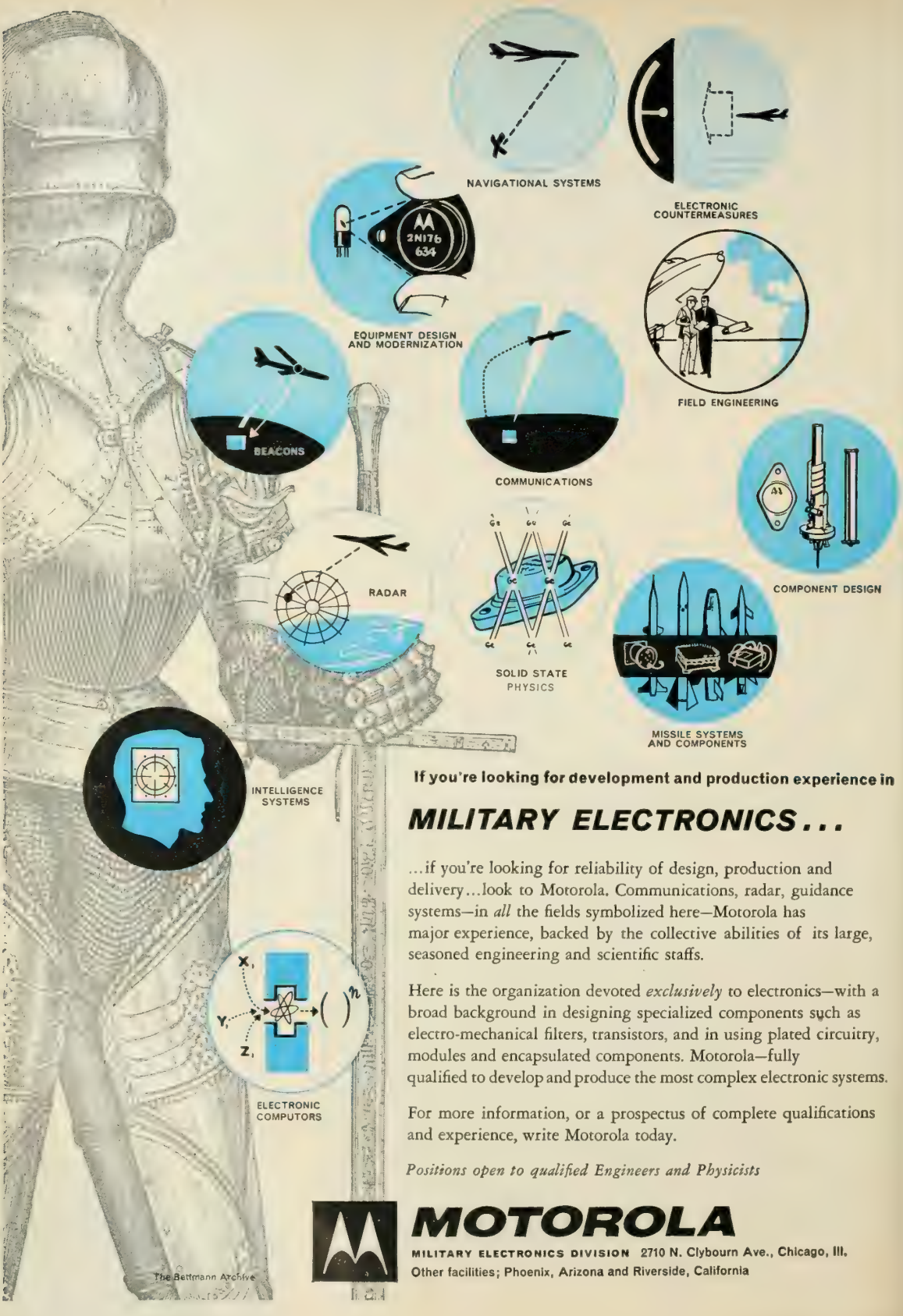
A good example is the problem of turbopumps. Pound for pound, the rocket engine turbopump is probably the most powerful pumping device ever developed by engineering skill. Because of the rigid requirements of turbopumps, Rocketdyne engineers have undertaken the analysis, design, development and testing of high pressure ratio supersonic turbines, high-speed gear boxes, radial and axial flow pumps, rotating and liquid gas seals and other mechanical components. The development of each presents a challenge.

In the field of instrumentation, the challenges have been similar. Typical of electronic advances at Rocketdyne is the IDIOT (Instrumentation Digital On-line Transcriber), which converts rocket engine test inputs at the rate of 10,000 per second, recording the numbers in binary code and magnetic tape. By playing back the tape through a digital computer, it is possible to process 4,800,000 separate readings in less than 15 minutes. Thus long range propulsion test data is almost immediately available for analysis, and performance improvement time is greatly reduced.

Such developments are significant in view of the fact that the tempo of our long range missile development—for the Nation's defense and for exploratory space travel—is governed only by the rate of our technological advancement.★

This pump shaft leads to underground receiving tanks at Rocketdyne's Neosha, Mo., plant. The company began moving in last month.





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Inertial Guidance for Air Force High-Punch Missiles

Jam-Proof Guidance Has Come a Long Way But Accuracy Still Remains Big Problem

By J. M. Slater

Autonetics Division, North American Aviation, Inc.

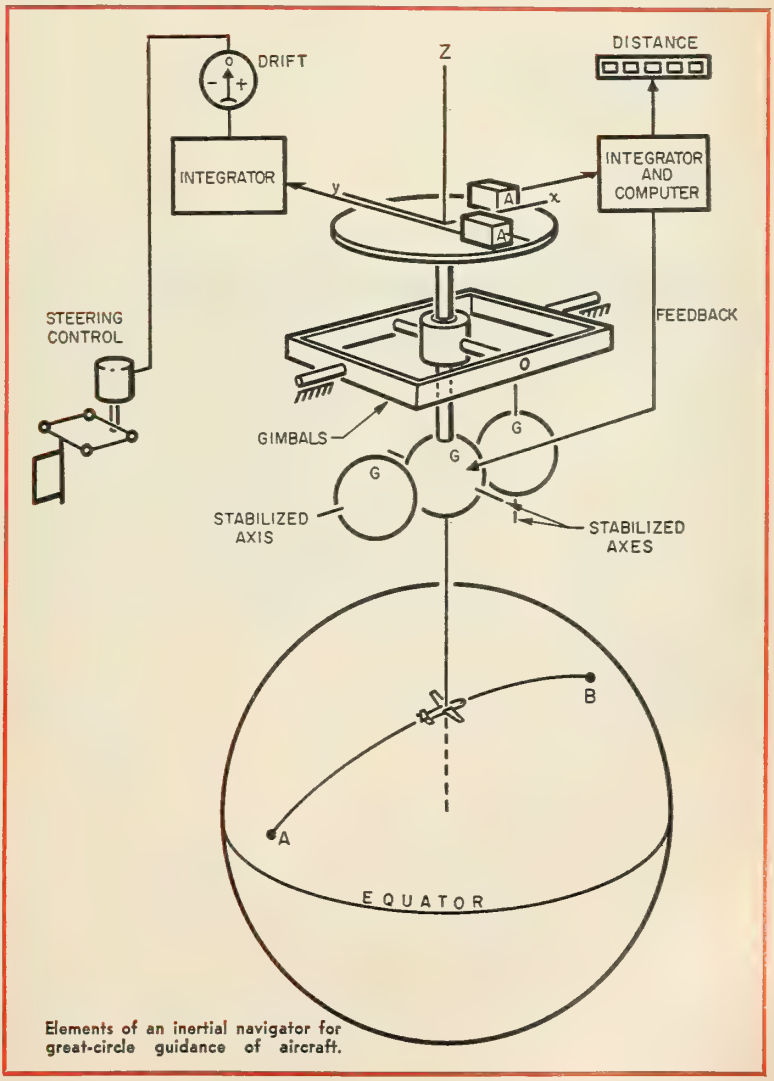
INERTIAL GUIDANCE is the science and art of determining a vehicle's velocity and position and other quantities necessary for guidance, by measuring and integrating accelerations.

Inertial guidance is an absolute method, one which makes its measurements in terms of mass, length, and time—as interrelated in Newton's second law of motion. It can be a strictly self-contained system, not requiring any information from outside. Its ultimate accuracy is limited only by the degree of the instrumentation's perfection. In ballistic-rocket guidance the operation is primarily one of establishing the correct initial velocity (speed and direction) during the boost stage, for a trajectory or orbit which will intersect the target. All the guidance occurs in the first few hundred seconds, after which a "free fall" condition obtains.

The heart of the system in each case is typically a set of orthogonally disposed accelerometers capable of producing an output signal linearly proportional to acceleration (or to a time integral of acceleration). The accelerometers are mounted on a gimbaled, gyroscopically stabilized platform, to establish a fixed coordinate system unaffected by maneuvers of the craft. A computer integrates the accelerometer signals to determine velocity and position, and feeds back signals to the accelerometers, the gyroscopes, or both, for compensation of disturbing factors.

Aircraft Navigation

In Fig. 1 a stable platform is shown as part of a representative system for guiding an aircraft on a great-circle course from a point A to



Elements of an inertial navigator for great-circle guidance of aircraft.

a point B on the earth's surface. The accelerometers are disposed along course and transverse to course.

Any transverse acceleration—due, for example, to a cross-wind—is detected and integrated twice with respect to time, the second integral corresponding to distance off-course (drift). The rudder is controlled from the drift meter in the proper sense and amount to keep drift zero. In the case of a cross-wind the aircraft will thus be automatically pointed into the wind at the correct angle.

Longitudinal acceleration must be sensed and integrated to determine distance traveled. Now gyroscopes tend to remain angularly fixed in inertial space. Therefore in the absence of control, the gyroscope assembly would not follow the curvature of the earth as the aircraft moves from A toward B, and the longitudinal accelerometer would be progressively tilted backwards. This is undesirable, as a component of the acceleration of gravity would be sensed, and confused with acceleration of the craft. To prevent this, a feedback of single-integrated acceleration is provided as a control torque on the gyroscope which stabilizes about the transverse axis. With proper adjustment of scale factors in the feedback channel, the gyroscope can be caused to rotate (precess) in space about such transverse axis y, at exactly the same angular velocity as that of the aircraft about the center of the earth. Thus the accelerometer table is kept level.

A very important consequence of this feedback is that the system is given the properties of a long-period simple-harmonic oscillatory system. If scale factors have been properly selected, the oscillation period (as measured at a stationary point at the earth's surface) turns out to be equal to two-pi times the square root of the quantity: earth's radius divided by the earth's surface gravity (g). This is the so-called Schuler period, and one result following from its use is that acceleration errors do not yield a cumulative position error, but rather an oscillatory error.

So far, earth rotation has not been mentioned. It must be compensated, because the gyroscopes in themselves cannot distinguish between rotation of the earth relative to the aircraft and rotation of the aircraft about the center of the earth. In general some component of earth rotation appears on each gyroscope, and must be compensated. The computer applies control torques thereto, as a function of position along the course, to synchronize them with the rotation of the earth. Thus earth rotation is cancelled out.

Earth rotation, however, can still give rise to certain accelerations which do not correspond to changes in vehicle movement relative to the earth—the quantity of interest. Among these are centripetal acceleration associated with the earth's rotation angular velocity, which is sensed at the accelerometers even when the aircraft is stationary; also the horizontal component of the acceleration of Coriolis, which is a function of aircraft velocity as well as earth angular velocity. The total magnitude of these accelerations is usually at most only a few per cent of that of gravity. Compensations may be computed by the computer and applied as biases to the accelerometers to "blind" them in effect to these false inputs.

Ballistic-Missile Guidance

The operations in guiding a ballistic missile are closely related in principle to those performed in precision gunnery. In firing a shell the three predeterminable variables are inclination and azimuth of the gun and size of the powder charge, which last determines muzzle velocity.

In a ballistic missile the corresponding variables are inclination and azimuth of the missile and the velocity at time of cutoff of the rocket motor. After this point the missile follows a path determined by gravitational laws.

One can get a feeling for which variables are critical with the aid of a garden hose and nozzle. If it is held at an angle somewhere near 45 degrees, waving it up and down through a considerable angle will have negligible effect on how far the water goes. Swinging the hose sideways produces an aiming error. The same effect, amplified by the increased range, is present in ballistic missiles such that an aiming error of one milliradian—0.05 degree—produces an error of about one mile at a thousand miles. Equally critical in the garden hose experiment is manipulation of the valve to control the stream velocity.

The primary function of a ballistic-missile guidance system then is to insure that azimuth, inclination, and velocity at the time of rocket motor cutoff are correct for the given target. If it could be assumed that the missile would not be translated from a predetermined flight path in any direction by winds, unpredictable variations in motor thrust, or other agencies, during the powered portion of its flight, then it would be sufficient to set in predetermined values of these quantities.

Such a simplified guidance plan was actually followed in the early Ger-



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man V-2 rocket practice. Azimuth and pitch were established with the aid of a set of gyroscopes analogous to ordinary flight instrument gyroscopes, and cutoff velocity with the aid of a single-integrating accelerometer or "velocity meter" (of gyroscopic-pendulum type) disposed along the longitudinal axis of the missile.

Such a scheme is of limited application, both because of unavoidable factors which could displace the missile from the intended guidance path and of the difficulty of making the accelerometer respond only to the desired quantity, acceleration along the flight path. The direct-mounted accelerometer will, of course, respond to a component of the acceleration of gravity g, which component is equal to g times the cosine of the angle equal to the instantaneous inclination of the missile to the vertical. This angle is difficult to predetermine correctly so that a sufficiently accurate compensation can be made.

For high accuracy a three-axis gyroscopically-stabilized platform could be utilized essentially similar to that described for flat-trajectory navigation, except for having a third, vertical accelerometer-integrator channel.

A somewhat idealized and simplified system of this sort is sketched in Fig. 2. Assuming for the moment a non-rotating earth, the platform is initially set, and thereafter maintained orthogonal to the vertical guidance plane through AB. The missile typically takes off vertically, and during the powered stage is rotated through some predetermined angle W—using the stable platform as a reference—toward the target B. The x and z-axis integrated-acceleration signals give components of the missile velocity vector. Rocket motor cutoff is initiated when the magnitude of this vector reaches a predetermined value. The lateral accelerometer signals are integrated and used in a drift-corrector in a manner similar to that in airplane navigation.

Actually, due to the fact that the earth is rotating, the missile will appear to an earth-fixed observer to be deflected laterally during the ballistic phase of the trajectory. To hit the target, the *initial* conditions must be set so as to give exactly the right "lead." This problem does not apply to aircraft navigation, where earth rotation is continuously compensated.

Although the present article is intended primarily merely as a sketch of principles, a misleading impression of simplicity might be gained unless some mention is made of the practical problems of instrumenting inertial guidance systems. These are some of the most severe in the whole field of engineering and manufacturing technology. The technique is based on force-balancing and force-measuring operations of the most delicate and precise sort, which must be carried out under non-ideal conditions.

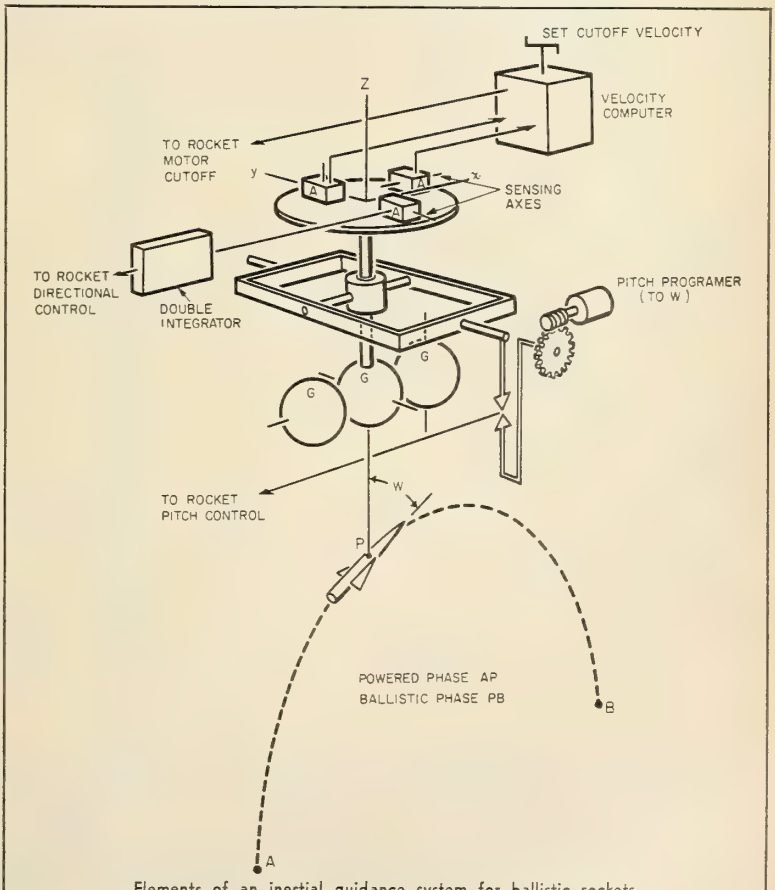
The most critical problems are associated with the gyroscopes and the acceleration-sensing devices. This follows from the very nature of the method. Thus, the gyroscopes are used, not as mere magnetic-direction or gravity-signal integrators or as rate detectors, but as a fixed or basic sort of reference.

In aircraft navigation systems, drift (angular wander) of the gyroscopes can give a position error substantially equal to the drift angle multiplied by the radius of the earth. Gyroscope drift is caused by stray torques acting on the gyroscopic element proper. A typical gyroscope of size suitable for use in air-borne equipment might have an angular momentum of, say, one million gram-centimeter-squared-radian-per-second. Now the torque corresponding to a drift rate of one minute of arc per hour (approximately equivalent to one nautical mile per hour error buildup in an inertial navigator) is only 0.08 dyne-cm.

This torque is equivalent to the gravity moment exerted by the weight of he paper *within* this letter (o), cut out and stuck on the gyroscope gimbal at a half-inch radius from the axis.

The acceleration-sensing devices have much the same quantitative requirement as the gyroscopes, in regard to allowable disturbing torque levels, i.e., a fraction of a dyne-cm, typically. The problem here is relieved to the extent that mechanically simpler constructions are possible for accelerometers. But on the other hand the requirement for exceedingly linear integration over a wide range often necessitates incorporation of at least one stage of integration into the accelerometer, as in the gyroscopic-pendulum type, for example.

The fact that inertial methods of velocity and position finding have been carried to their present level of accuracy and reliability is a tribute to the foresight of the national defense authorities for initiating, subsidizing, and maintaining the requisite intensive development programs. It is also a tribute to the scientific, engineering, and manual skills of the personnel involved in such programs.★



Elements of an inertial guidance system for ballistic rockets.

Fig. 2

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7	2300 cps.	S-60007	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
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9	3.9 KC	S-60009	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
10	5.4 KC	S-60010	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
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12	10.5 KC	S-60012	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
13	14.5 KC	S-60013	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
14	22 KC	S-60014	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
15	30 KC	S-60015	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
16	40 KC	S-60016	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
17	52.5 KC	S-60017	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
18	70 KC	S-60018	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
A	22 KC	S-60019	±15%	¾ x ¾ x 1⅜ H	1¼ oz.
B	30 KC	S-60020	±15%	¾ x ¾ x 1⅜ H	1¼ oz.
C	40 KC	S-60021	±15%	¾ x ¾ x 1⅜ H	1¼ oz.
D	52.5 KC	S-60022	±15%	¾ x ¾ x 1⅜ H	1¼ oz.
E	70 KC	S-60023	±15%	¾ x ¾ x 1⅜ H	1¼ oz.

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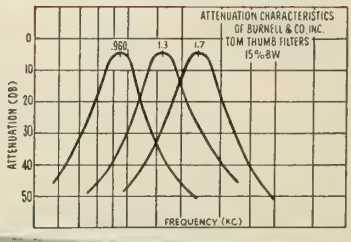
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Human Engineering in Weapon System Development

by David W. Atkins,[1] David M. Piatt,[2] Albert Shapero[3]

IN THE DEVELOPMENT of a weapon system, the role of human engineering is to optimize the man-to-man and man-to-machine relationships within the system. This has developed from a growing realization in the weapon system field that inadequate consideration of the human components in the system (operators, maintenance men, etc.) can mean marginal operations or failure of the system.

The human engineer's tasks are based on his specialized knowledge of the characteristics, capabilities, and limitations of the human as a component. Basically, these tasks are:

1 Determining the best distribution of functions between man and machines according to their respective inherent capacities and capabilities.

2 Assuring the optimum communication between man and man, and man and machine by the proper selecting, positioning, and linking of the men, equipments, and environments.

3. Assuring equipment designs which are optimized for ease of installation, maintenance, and operation.

4. Determining manpower and training requirements and evaluating human performance in the over-all system operation.

These tasks begin with the earliest phase of the weapon system development program and continue into its final evaluation stage. A fuller understanding of what the tasks are, what is involved in their implementation and their possible effects upon the program is of value to all who are connected with the management and implementation of weapon system development and operation.

Distributing Functions Between Men and Machines

Ordinarily design decisions are made on the basis of materials, components, and "state-of-the-art" electromechanical design techniques without any regard to the characteristics and capabilities of the human components of the weapon system. This failure to properly assay the role of the human component results in what can be called the accidental distribution of functions between men and machines.

Optimum as opposed to accidental distribution of functions between men and machines requires full consideration of which functions are inherently performed better by either men or machines, the economics of this distribution, and safety as well as the mission, electro-mechanical data, hardware availability, design limitations, and the other usual considerations. When men and machines are considered together there is a direct payoff in increased system operability and effectiveness which minimizes expensive design changes, operating errors, and operating and maintenance costs.

Psychological and physiological data, which make up the bulk of the human engineer's working material are utilized in making decisions in assigning functions to men or mechanisms. For example, by using this data the following general statements can be made:

SENSORY ABILITY: Except for the most complex instrumentation, human audio and visual sensing capacities surpass those of machines.

PERCEPTUAL ABILITY: Man excels at comprehending complex data.

ATTENTION: By being alert for changes, human beings can often anticipate undesirable conditions.

FLEXIBILITY: Humans are characterized by a flexibility of action which provides insurance against complete equipment system failure.

MEMORY: Man is more efficient in tasks requiring long-term memory.

JUDGMENT AND REASONING: Men are needed to make judgments when it becomes impossible to reduce operations to logical preset procedures.

SPEED AND POWER: Machines can make movements more smoothly, quickly, and powerfully than man.

REPETITIVE OPERATIONS: Machines excel in repetitive and routine tasks; unlike humans, machines do not become bored or inattentive.

COMPUTATIONS: Machines designed to perform specific computing operations are more efficient than man.

SIMULTANEOUS ACTIONS: Machines can be devised to carry on a greater number of simultaneous jobs than man.

There are two aspects to the economics of distributing functions to men or machines which demand consideration. First, there is the initial cost of the system. Secondly, there is the continuing or operating costs in the field. Building into machines functions that are normally associated with human abilities usually involves design complexity that increases the design and production cost. This must be balanced against the savings this design can effect in the operating costs in the field. Consideration of the economics involved in simplifying operations at the cost of increasing the maintenance burden can strongly influence design decisions as to whether a function should be performed by man or mechanism. For example, the decision to make a piece of equipment self checking has resulted in the ludicrous situation where the complex self maintenance features of the equipment required as much maintenance as the operating features of the equipment.

Safety and Cultural Considerations

Every society imposes conditions and limitations upon treatment of human beings. These are a function of the culture and must be taken into account by the human engineer during the design of the weapon system. Often this is done by designers without conscious examination of the problem. Among these conditions and limitations are those associated with safety, body usage, and instrument design.

During World War II, Russian fighter pilots extensively employed aircraft ramming tactics in combat. In addition, the Russian Air Force had the armor plate removed from American aircraft delivered to them to increase the aircraft performance at the expense of pilot safety. In both cases, American attitudes toward the value of the individual significantly affected flight tactics and consequently aircraft design. The deliberate expenditure of a pilot's life as part of weapon system design was also employed by the Japanese in World War II. The use of man as this type of guidance system would be unacceptable to all Western cultures despite the calculated payoff.

Cultural reading habits would dictate that the typical Western nation instruments arrangement should probably be from left to right and top to bottom. However, such a scheme would not be optimum for Chinese, Arabic,

[1] *Supervisor, Human Factors Group, Radioplane Co.*
[2] *Litton Industries*
[3] *Supervisor, Weapons System Operations Section, Radioplane Co.*

or Israeli operators whose lifelong reading habits condition them to reading and writing (and thus scanning) in different directions.

The use of the human body for operating or sensing tasks also is limited by the taboos and practices of the society. For instance, our culture would not accept the use of radical surgery or prolonged and habitual use of dangerous drugs to increase the utility value of a human component.

Linkage Between Man and Machine

In the past it has been a rather common belief that a man could operate almost any kind of equipment. Little thought was given to the physiological and psychological capacities and limitations of the humans charged with the operation and maintenance of complex systems. As a result the operator is generally provided with displays and controls designed primarily to engineering criteria which ignore his limitations.

When men and machines are required to work together it is important that the machines provide required information in such a way that the human operator can make an exact interpretation. The information transmitted by the machine to the operator must permit him to make required judgments and to act quickly, decisively, and correctly. This means that the design and placement of indicators and controls must be on the basis of the real capabilities of the operator rather than on theoretical capabilities. Some data can be much more readily accepted than others. Humans are also capable of producing a wide variety of control outputs, but again, they perform some much more rapidly and accurately than others.

In dealing with the complex tasks involved in operating weapon systems, it is obvious that even if the human operator could correct an error, there might not be time for secondary actions. The sequence of many operations is complex, precise, and in its final steps, irreversible. Thus, it is of prime importance that judgment errors are minimized by designs requiring only those human decisions which can be made correctly and within the required time limits. Good human engineering makes it possible for the operator to act decisively, selectively, accurately, and quickly. It further assures design of the human requirements with regard to the learning capability of the personnel who are to operate and support the weapon system. Thus the operator is only required to do things that he can be taught to do reliably.

It is probable that in most weapon systems of the foreseeable future, control functions will be performed primarily by humans or there will be semi-automatic control supplemented by human performance of certain critical functions. In either case the linkages between man and machine will be rather complex. These man-machine linkages have two main forms—displays which communicate data from the machine to the man, and controls which communicate instructions from man to machine.

The Human Element

In a man-machine system displays are used to present information to the human element. Usually, this is done through either the visual, auditory, or tactual senses, or some combination of the three. The best type of information display is the one which cuts the lag in perception to a practical minimum. That is, the data inputs to the human operator must be such that they can be readily accepted and interpreted.

Once the necessity of presenting certain information content to the operator has been established, the human engineer is guided in the selection of the type of display by many considerations. For example, in deciding whether to present information visually or auditorily the human engineer knows that, in general, the eyes are a better medium when it is necessary to present relational or other complex information. On the other hand, the ears are a better sensory medium when dealing with (1) alarm signals, (2) displays where reaction time is important, and (3) where information input is low but continuous.

Auditory Radar

In the past, most information has been displayed visually for equipment operators. In many cases this has resulted in an overloading of the visual senses. Further, some of the more recent investigations indicate that some information now presented visually could just as well be presented auditorily. For example, techniques have been developed at the Air Force Cambridge Research Center for effectively presenting certain types of radar return information through earphones rather than displaying it on a scope.

The human operator directly affects the weapon system through the operation of controls. The best controls are those which minimize the probability of operator error and which permit the operator to transmit the proper action with ease and speed. Hence, in fulfilling his role of optimizing human performance, the human engineer must insure that equipment controls are designed so that they most effectively transmit the operator's intentions.

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Considerable work has been done in the past on such problems as the design and arrangement of visual displays controls, designing control systems in which non-linear relations between controls and displays are used to meet wide variations in speed and accuracy requirements and coding of controls to facilitate identification.

For example, it has been found possible to code controls by shape so that even with gloves on, an operator can immediately tell which knob he is touching without having visual access to it. Efforts are now under way to standardize certain of these shape codings for various functions on different pieces of equipment.

Usually it is necessary to consider display and control problems concurrently, since equipment operators customarily receive information from displays, process it, and respond by initiating control movements. In maximizing this behavior cycle the human engineer applies his knowledge of human perception, higher integrative mental processes, and characteristics of motor behavior.

Man-Man Linkage

To fully utilize the human component and integrate him into the weapon system it is necessary to consider not only the interrelationships between man and machine but also those between man and man. When men perform as a team or when information is transmitted and received directly from man to man within the system operations, it is the human engineer's task to see that the design is such that these operations are designed with regard to man's capabilities.

Optimum Design for Maintenance

Maintenance problems demand consideration during initial equipment design. It is both possible and desirable to engineer equipment for maximum usefulness and minimum maintenance. Human engineering's aim is to achieve a design that is optimized not only for operability but maintainability also.

In discussing the assignment of functions to men and machines earlier in this article, the importance of maintainability factors was mentioned. It is recognized that when human functions are mechanized, the complexity and maintenance requirements may be increased. Similarly, in determining test requirements for equipment, a balance is struck between mechanizing of test and self-test functions, and the burden of tester maintenance imposed by the complexity of its own functions.

On the other hand, the capabilities and limitations of the human are essential considerations in determining maintenance tasks, component accessibility tools, techniques, test equipment.

Maintenance involves a certain amount of decision making, such as: What unit is malfunctioning? What should be done to correct this malfunction. Can the required operation be successfully completed despite the malfunction? The factors involved in making such decisions are so complex and unpreditcable that at the present time humans are generally much better able to make them than are machines.

Manpower and The Basic Training Requirements

The human engineer is directly concerned with the determination of the requirements for weapon system manpower in terms of types, skills, numbers, and training.

While the ability of human beings to accept data, make decisions, and manipulate controls can be modified by training, lengthy and expensive training programs are not the proper or economical method to compensate for poorly designed controls and displays. However, the design of displays and controls together with many other factors determine training requirements for bringing operators and mechanics to the desired level of performance.

In establishing training requirements, the human engineer considers every task to be performed in the installation, operation, and maintenance of the weapon system. The tasks are then grouped and positions or jobs are defined. On the basis of previous knowledge and assumptions about the capabilities of the personnel who will fill these positions, training requirements can then be established. Here the human engineer utilizes his general psychological background and his specific knowledge of learning theory.

In the area of training methods and devices the human engineer determines what parts of complex tasks must be trained realistically rather than by simulation methods, and how training devices can be simplified by eliminating hardware which is not needed for efficient training.

Machines can be designed to be simple to operate regardless of their inherent complexity. The tasks of men and machines can be analyzed and properly separated to reduce the error exhibited by either. Malfunctions can be minimized by considering the malfunction problems from the beginning rather than at the end of the development of a piece of equipment. ★



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LEARN and EARN

. . . Air Force looks to Systems Labs for unique program to keep the U.S. supplied with rocket engineers

by Fred S. Hunter

SYSTEMS LABORATORIES CORP., incorporated only last May, already is a million-dollar-a-year business, and the work load on the president's desk keeps increasing.

This may mean that its president, Dr. John L. Barnes, who teaches two engineering classes at the University of California at Los Angeles, will have to cut—reluctantly—to one.

But no matter how great the flow of papers across his desk at Systems Labs, Dr. Barnes will devote some portion of his time to the classroom.

"Continuing to teach is a way to keep in touch with your engineering," said Dr. Barnes. "Otherwise, next thing you know, you are 100% management." Dr. Barnes wants to be sure to retain his identity as a scientist.

Systems Labs has a number of distinguishing features: it is the first scientific corporation of its kind to specialize in interplanetary space travel, research and development; it is owned and managed by the scientists and engineers who comprise its staff; a scholastic atmosphere pervades throughout its operation.

It probably has a higher percentage of Ph.D's on its payroll than any comparable institution in the country. It also has a graduate honors program that puts the company in something of a class by itself.

A number of large aircraft corporations are offering scholarships and other educational assistance to graduate engineering students to pursue advanced degrees—and as an inducement in personnel recruiting—but no small companies have felt able to undertake the expense until Systems Labs came along. It's indicative of the imaginative characteristics of Systems Labs' activities that close to 500 applications were received by the company from graduate students in the U.S. and abroad within a month after Dr. Barnes announced the fellowship program.

Systems Labs' scholarship program provide full tuition, books and supplies at one of the three graduate schools in the Los Angeles area, the University of Southern California, the University of California at Los Angeles and California Institute of Technology. It is open to graduate students in the physical sciences, mathematics and engineering, who are in the top 10% of their class. Science bachelors working for masters and masters seeking doctorates are eligible. A graduating senior may continue his education right through to a Ph.D. under the program.

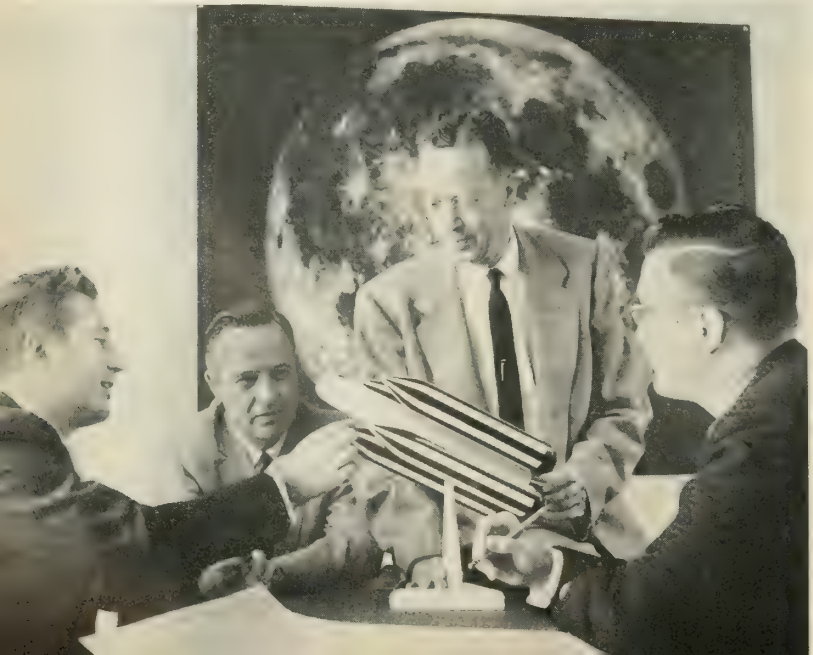
Candidates are put on salary as soon as they arrive and work full time at Systems Labs during the summer. During the first semester, 80% of their time is devoted to study, 20% to work; during the second, 40% to work and during the third 75%. Starting salary is stepped up four times during the full course of the training program.

Each student is assigned to a "staff mentor"—one of Systems Labs' top scientists or engineers, and works closely with him during the training program. Upon completion, the candidate is free to continue on Systems Labs' professional staff or seek a position with another company.

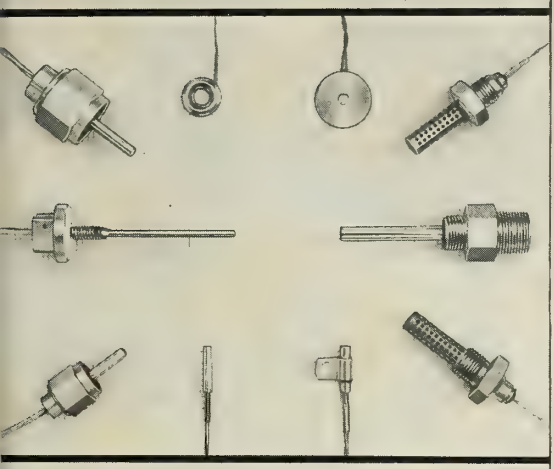
One of the world's leading authorities in electrical engineering, and co-author of "Transients in Linear Systems," the standard text in the field, Dr. Barnes is especially aware of the importance of "feed-back" in the complex circuit of human relations in scientific research and advancement. "Top quality people in an optimum environment turn out the best research," he explains. "You can't keep people unless you learn what they want."

Systems Labs' can be described as a small company with big objectives. "We don't want to get too big," says

President J. L. Barnes briefs Systems Labs staff members on moon rocketry. Left to right: R. H. De Lano, Electronic Weapons Systems Coordinator; Dr. Lewis Larmore, Superfrequency Sensors Director; Dr. Barnes and Dr. J. A. Marsh, Radiofrequency Sensors Director.



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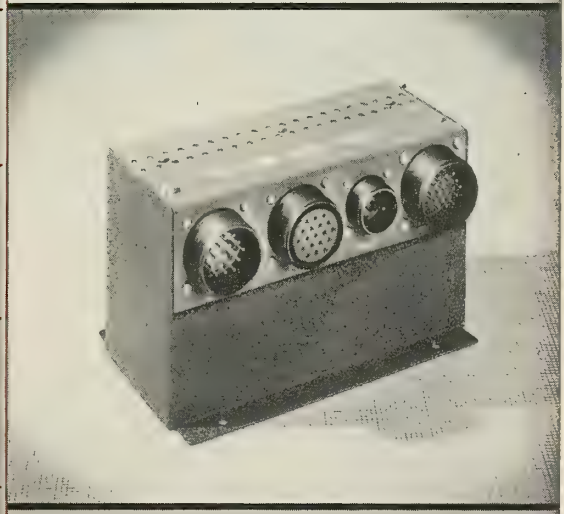
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- No vacuum tubes or transistors used.
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L. K. Edwards (center), head of the Advanced Design and Systems Analysis Department, discusses atmosphere effects on missile guidance with W. F. Wright (right), head of the Analysis, Plans & Reports Section, and A. L. Lowell, Advanced Design Staff Engineer

MISSILE SYSTEMS ANALYSIS—*a field of varied assignment*

Engineers and scientists seeking a wide range of assignments will be interested in Lockheed Missile Systems Division's concept of systems analysis. For at Lockheed, systems analysis responsibilities involve virtually every phase of missile preliminary design and development. Essentially, engineers and scientists in this department formulate overall analytical treatment; perform original analyses when problems defy conventional handling; coordinate analytical activities among different departments.

Present openings are in areas related to inertial guidance, functional systems, power plants, control systems and overall weapon configuration. Openings are at Sunnyvale and Van Nuys Engineering Centers.

Inquiries are invited from engineers and scientists whose ability and aptitude demand a wide range of assignments.

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Dr. Barnes, even though he admits bigness is of itself often an advantage. "You can get contracts on bigness alone," he points out.

It will take $15 billion to circle the moon—one of Systems Labs' big objectives. This means, of course, that no agency other than the government can finance it. But, as Dr. Barnes points out, this is not the kind of project you undertake in one chunk. It is something to be done a few millions—or billions—at a time.

Systems Labs charter states that the corporation was organized primarily to work on interplanetary travel. Meanwhile, it is bringing in its revenues from sub-contracts. At this writing it has 15 of these, all scientific projects. Included in the first sub-contracts obtained by Systems Labs were four from Republic Aviation to solve problems in guided missiles and aircraft fire-control.

Systems Labs expects to begin getting some prime contracts very soon. They may even be in the interplanetary field. Dr. Barnes hints that more than one government agency is beginning to look in this direction.

As Systems Labs' grows, Dr. Barnes plans to partition it off into semi-autonomous sections. He envisions a number of separate laboratories at various points on the west coast, Santa Barbara, LaJolla, Corona del Mar, perhaps even in other sections of the country. Dr. Barnes wants a ceiling of 100 employes in any one section. Better communications and better work are the twin accomplishments of groups held to a maximum of 100, he believes.

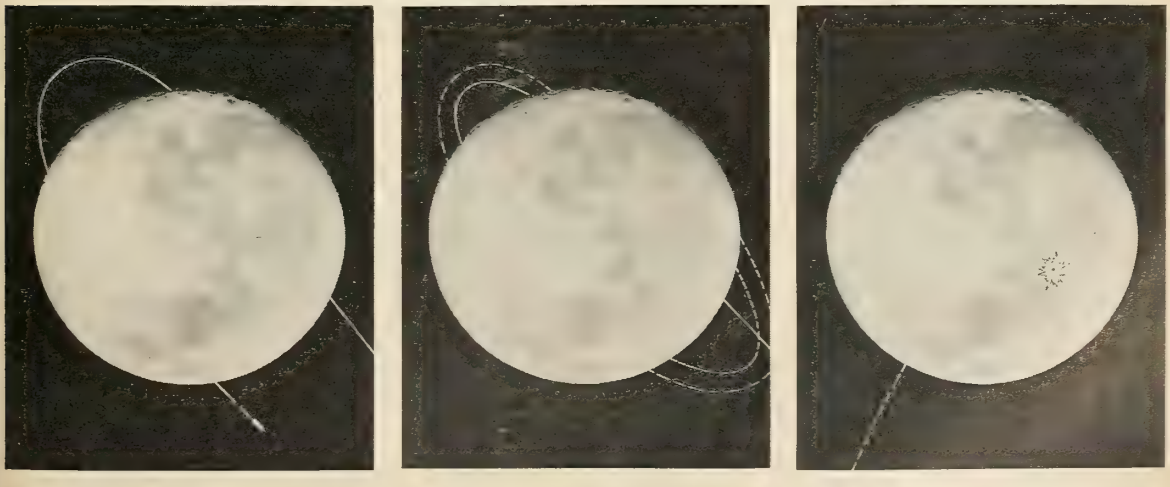
The first separate laboratory probably will be a radar antenna laboratory. This is logical because he has the man to head it up, Dr. James A. Marsh, who, says Dr. Barnes, is a good scientist and also a good administrator. Formerly head of North American Aviation's radar group at Downey, Dr. Marsh is one of the founders of Systems Labs. Another is Richard H. De Lano, one of the co-holders of the *Falcon* missile.

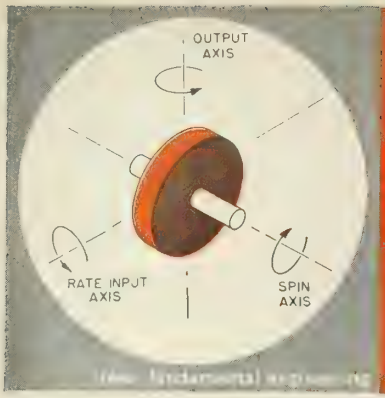
Dr. Barnes and his associates believe interplanetary travel will actually be easier than generally expected. The numbers, they say, are all coming out right in Systems Labs' initial studies of the various phases. They're watching nuclear power developments closely and unless there are unexpected throwbacks here Dr. Barnes doesn't think it at all optimistic to say that the next few years will see the development of a practical moon rocket project. ★

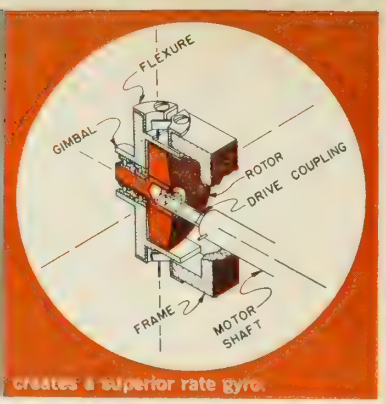


Dr. John L. Barnes, President of Systems Labs which weans students slowly from the classroom to the laboratory working up from a 20 per cent work-day to 75 per cent in the last year.

Three methods man may employ in trying to get his first closer look at the moon—around and back; up and orbit; and a visible impact on the moon's surface. Any one of these is the kind of project Systems Labs was set up to develop. It is also the kind of a project AF's Western Development Division is preparing to launch.







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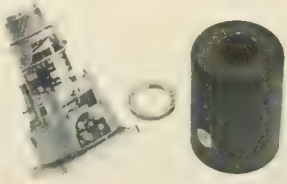
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international briefs

ICBM Won't Replace Manned Bombers

Air Chief Marshal Sir Dermont Boyle, the Royal Air Force's Chief of the Air Staff, stated in Australia last month that intercontinental ballistic missiles would never completely replace the manned strategic bomber. The primary problem of all modern aerial planning centered on the change from manned aircraft to guided missiles, he declared. Some authorities thought the change would take place overnight, others that it would never take place.

Meanwhile the Chairman of Bristol Aircraft Ltd. and President of the Society of British Aircraft Constructors, C. F. Uwins, who was also visiting Australia, urged in an interview that some of the secrecy surrounding British guided missile development should be lifted. He said this would have a very good effect on the morale of guided missile workers.

Uwins revealed that more than 400 British companies are now working on guided weapons, including long-range ballistic missile.

Oil Spraying Rocket For Mercy Missions

From Bremen, Germany comes news of rocket development for mercy missions. The Deutschen Arbeitsgemeinschaft fuer Raketentechnik has designed two models of an "oil-spraying" rocket for reducing the heights of waves around a vessel in distress. In principle, the rescue ship (Coast Guard) would fire a series of these rockets up wind of the disabled vessel to lay down an oil slick prior to rescue. The rockets are designed to be fired from the standard rescue-line throwers. Only prototypes have been manufactured so far and tests are anticipated.

French Determine Fuel Erosion Constants

The French have come up with novel ways to determine the erosion constants of solid propellants. One method used two nozzles with a progressive burning grain—a large steel nozzle to maintain pressure and a smaller nozzle to test the propellant. Another method uses an erosion bomb which compares two grains.

Yet another French work tackled an old propellant—black powder for rockets. The exponent of burning rate was about 0.62 at pressures up to 800 mm Hg. At atmospheric pressures, the fastest propellant had a burning rate of 0.46 in/sec and consisted of 5% S and 20% C. For smoother low pressure operation, the best composition was found to be about 25% S and 20% C.

all at once...

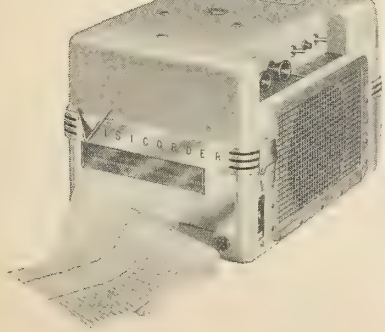


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International Scene



By Anthony Vandyk

Naval minesweeping techniques are used in a missile recovery system developed at Australia's Woomera range. Designed to protect valuable test missiles and their delicate instruments from damage, it employs a long cable attached to and reeled out from an aircraft. At the far end of the cable is a winged paravane which flows like a kite 400 to 500 ft. from the side of the aircraft. The missile is equipped with a small parachute which is automatically or electronically released at the end of its run. This parachute is not big enough to support the missile in the air but it checks its falling speed. The aircraft then closes in and sweeps the cable of the aerial paravane across the cable of the parachute. The parachute cable slides along it until grappled by the paravane. The recovery point is another cable slung at the top of a ravine or between two towers. It collects the missile from the paravane as the aircraft flies past. m/r's Australian correspondent comments: "This development calls for rather tricky flying!"

•

Rolls-Royce is building the North American Aviation rocket motor under license for use in Britain's IRBM. Work on this project has been in progress for some four years. Meanwhile the British Army is putting final touches for plans for the use of its U.S.-supplied *Corporals*. Present indications are that the English Electric Company will handle the overhaul of the Corporal in the U.K.

•

It's no secret that the Royal Air Force thinks very highly of infra-red missiles and is counting on the de Havilland AAM of this type to play a major role in the air defense of Great Britain. One reason that infra-red missiles are preferred to radar-guided types is that the former are less susceptible to jamming.

•

"World-wide circulation" is being given to a notice by de Havilland Propellers Ltd. that this company is responsible for the de Havilland guided weapons program—not the de Havilland Aircraft Company. The propeller company is one of three operating companies (Aircraft, Engine and Propellers) within de Havilland Holdings Ltd. in Great Britain. In Australia the propeller company has set up facilities at Salisbury and Woomera with administrative assistance from de Havilland's Australian subsidiary, de Havilland Aircraft Proprietary Ltd. De Havilland-Canada has established its own Guided Weapons Division with the assistance of de Havilland Propellers Ltd.

•

The Royal Air Force has formed special units to conduct service acceptance trials of missiles under the control of the Ministry of Supply. RAF men for these units are attached to manufacturers during the development stage. After acceptance trials they will carry out the service trials of the weapons in the RAF. In another phase of missile work the RAF has formed its first guided weapons training station. A simulator is being built at this facility (location secret) which can synthetically reproduce attacks by enemy aircraft and enable interceptions to be practiced under realistic conditions.

•

The Paris International Air Show May 24-June 2 will be used to unveil a lot of new French developments in the missile field. It is probable that SNECMA will be able to reveal some details of its work on ramjets. SNCA du Nord is likely to have plenty of missile hardware on show. The show is held at Le Bourget airport and has representation not only from French manufacturers but from nearly every European country plus Canada and the U.S. Several of the East European countries are planning to participate.

MICROWAVE AND ANTENNA ENGINEERS

Experienced microwave engineers are required to perform research, development, and design on antennas, radomes, and microwave components. System engineers are needed for system development related to microwave receivers, Electronic Reconnaissance, Countermeasures, Radar and Transponder Systems. The work will be accomplished in the Radiation Laboratory in relation to prime missile and airframe contracts.

AUTOMATIC CONTROL SYSTEM DESIGN ENGINEERS

Engineers are required with experience in closed loop stability analysis and synthesis of automatic control systems. System engineers are needed for design and development of servomechanism, memory circuitry, digitalanalogue techniques, and numerous other control equipment for fulfilling the requirement as specified by system analysis design studies. These engineers will perform research, development and design of stabilization and control systems for guided missiles and high performance aircraft prime contracts.

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TELEMETRY ENGINEERS

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World Astronautics

By Frederick C. Durant III

For the next 5-10 years the unfolding of satellite vehicle research programs will represent the next major step in the development of astronautics. Soon the first handful of 20 in. NRL telemetering spheres will be flung into satellite orbit around the earth as part of the U.S. IGY program. The USSR, too, will launch IGY satellites of size and orbits still to be announced. As discussed previously in this column these initial programs will be followed by satellites of increasing dimensions. Eventually, man will travel in satellite flight.

To report clearly to the public on these events will require a depth of perception that is not common in news agencies today. Understanding and appreciating the satellite program's significance will be necessary to properly tell the story to the public.

Executive elements of our news and communications media must become educated to the fact that space flight can no longer be treated in a tongue-in-cheek manner. This approach, widespread until recently, masked a lack of understanding of what space flight was all about. But astronautics has now reached the age of respectability. Industry and Defense Department attendance of the Convair-OSR symposium last February significantly underlines this fact.

The problem of lucid commonsense reporting and interpreting such news events as the *Vanguard* test launchings and subsequent live firings is facing all news editors. To meet this challenge every major radio and TV network, wire news service, newspaper chain and news periodical should be undergoing self-education. At least one or more responsible staff members should now be charged with the responsibility of learning the basic facts of astronautics.

The public is understandably confused about space flight. There is deep interest but there are many misconceptions about the relative size of the problems and probable time table of realization. Above all, they want to know the *why* of space flight. What will astronautics mean directly and eventually to the man in the street, to scientific research, and to industry? When, and how, will astronautics affect our economy?

The rocket and guided missile industry and the professional societies have a major responsibility in providing facts and understanding through popular lectures, brochures, films, and consultancy. There have already been excellent examples of these such as Martin's booklet, "A Moon is Born" or their film "Horizon Unlimited," or G.E.'s "Rocket Facts." However, the quantity of such material is still far too small in the face of the rate of rocketry progress.

In the course of talks on rocket power which your columnist regularly gives to professional society gatherings it is still startling to find that discouragingly few persons know what the letters IGY represent. Still fewer can tell you why the e.s.v. program is revolutionary, or what it portends. As for the man in the street, the level of knowledge is still lower. And yet the subject relates to the most exciting adventure and exploration expedition to be undertaken by civilized man. The majority of people now alive will witness manned space flight and, at least, lunar expeditions in their lifetimes.

The communications media have the opportunity to provide the public with a sound understanding of the next basic steps in satellite flight achievement. More than an opportunity, it is a responsibility.

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The Ballistic Missile Challenge

. . . as seen by Major General Bernard A. Schriever

Chief, Western Development Division of ARDC

Q. *General Schriever, does the management organization here at WDD function as one team?*

A. Yes you can't really distinguish organizational lines between WDD, R-W and BMO. It's one integrated operation. We work as one management team. Not that we don't have problems from time to time, we do; but to all intents and purposes we function as a closely knit team. I have more problems internally within my own staff than I do in keeping the R-W, BMO, and WDD all working together.

Q. *I notice everyone wears civilian clothes. Why is that?*

A. There are really two reasons for it. The first one has to do with security. When we first came out here we felt that to enter into a civilian community and have a lot of officers running around would immediately create speculation which we felt not in the best interests of security of the program of the Air Force. That was reason number one.

Reason number two is that we feel that everyone working in civilian clothes actually creates just a little better spirit of harmony or establishes conditions where you can work in better harmony. If I were sitting here with two stars on every day, I think the people coming into my office would be just a little bit more apt to be formal and stiff than if I'm sitting with a sports jacket on and a pair of brown trousers.

Q. *Is it true that $470 million have been spent on test facilities since the program was accelerated in August 1954?*

A. Well, not just test facilities, this includes plant expansion, too. Let's take the North American Rocketdyne plant at Canoga Park as an example. The plant that was built in Denver by Martin is another. So is the plant that is being built right now by Convair. However, the largest percentage of this total of $470 million has been for test facilities—major test facilities—and also test equipment which you never see.

It's an environmental type of test equipment; shake tables, centrifuges, furnaces of different types, shock tubes and things of that nature which are small but expensive. They are the kind of things that we have to have to start testing the reliability of the components before they are assembled into a subsystem. Then, of course, facilities get larger when you start testing subsystems. When you start testing the entire missile with the subsystem assembled then they become quite large.

I think a comment on the test facilities and their possible use for follow-on program would probably be an interesting point as well. You take the North American test stands that we have at Santa Susana; I don't remember how many stands were there when our program started, but in 1954 when we started the accelerated program there were something like four or five, I think. They have quite a few more than that now and they were all built in support of the Ballistic Missile program. All of the stands built at Aerojet in Sacramento, for example, were built for our Ballistic Missile program.

Q. *Will these stands have continued utilization for future development?*

A. Yes. For example, a stand at Edwards which we're just activating now—Stand 1-A—will take a million pounds of thrust. Actually, when you get the safety factors in there you will probably be able to go up to a million and a half pounds. Of course, we don't propose to test anything in this program that has thrust of that magnitude.

Q. *Then, you don't rule out expanded tests in the future, for space flight, for example?*

A. Resources in manpower and facilities and the knowhow in fabrication and techniques that have been established to date and are still on the build-up, are of such a magnitude that the business of space flight is just a matter of whether or not you want to do it and want to spend the money on it. It's no longer a matter of technology or a



The business of space flight . . . a matter of whether or not you want to do it . . .

matter of resources in terms of the facilities and know-how. It's a matter of the funds and the need for doing it, either in terms of military requirement or in terms of national prestige.

Q. *Do you think there is a military requirement for spaceflight?*

A. Certainly, military requirements can be formulated—just one in terms of reconnaissance, that relate to other phenomenon; that relate to matters of the earth's gravitational field, cosmic rays and that sort of thing—these can all be applied to the military. But if you want to be more specific in terms of having space vehicles out there trying to shoot each other down or delivering weapons by space vehicles this is something that I am not able to comprehend in terms of specifics yet.

As we move out into space, I think first it will be to get scientific data. From there, once you get moved out into space, you're going to start identifying specific things that will relate to a specific military mission. I'm sure of this. I think this is an evolutionary thing, and I'd certainly not try at this point to lay out a blueprint as to what this might look like.

Q. *Going back to the $470 million which was spent on facilities, and test stands and what not, does that amount include the scientific study contracts that have been let in the same period?*

A. No, this covers only the actual facilities.

Q. *How much money has industry put in?*

A. When you add up all of the industry facility investments, they total slightly over $100 million. This is industry money out of that total of $470. But here again, like the Martin construction, all of the construction isn't quite complete yet. Neither is the Convair construction program. The Aerojet facility construction is almost complete. So is the North American Rocketdyne facility in terms of their investment.

Q. *What can you say about the progress of the program since you took it over?*

A. Well, actually, I divide the program into four phases and perhaps I should discuss very briefly each one of these phases. The first phase really was a study and organizational phase. After the von Neuman committee made its recommendations to the Air Force that we should accelerate the ICBM program they didn't say take the program that the Air Force had in being then and accelerate it. They said that we should conduct very detailed technical studies and systems analysis to bring about a reoriented program within one year's time. This was to assume maximum benefit from the thermonuclear breakthrough that had occurred. This actually changed the nature of the weapon system in terms of its military characteristics.

First we conducted very exhaustive technical studies and system analysis. At the same time we established this management complex—the administrative actions required to set up the management establishment to clarify procedures, get personnel into place and so forth.

Next we made the major technical decisions that launched the development program that followed. I mean the reorientation of the *Atlas* and a number of other things of a technical nature. That ended phase one. Phase two was relatively short and involved the selection of our industry team. We had to select the total contractor team-guidance contractors, which included both radio-inertial and all-inertial; the computer contractors that went into the radio-inertial guidance contractors; another large liquid rocket development and production agency; the nose cone contractors of which we selected two.

Then we introduced a second approach, a second or alternate ICBM approach which was very, very strongly recommended by the scientific advisory group which kept in being with Dr. von Nueman as chairman. We had frequent meetings with that group.

Q. *Was the von Nueman committee organized strictly to monitor the Ballistic Missiles?*

A. Correct. It was during the second phase then that I considered the selection of the industry team. We of course kept the program going and accelerated both contractors that we had in being. At North American we had to put a great deal more money there during '54 to expand the facilities. We kept Convair more or less at the same level until we made a decision on what changes we wanted in their particular configuration.

When we had completed, for all practical purposes, the selection of our contractor team, the IRBM was not yet in the picture. Next would be what I consider the third phase, which I call the development, fabrication and test phase, which covers, you might say, the real development effort. This of course, had associated with it the vast facility program we've just discussed. Schedules are all paced on getting facilities in being on time, if you want to carry out a crash program. I think, from the standpoint of accomplishment, that getting this facility program accomplished essentially on time was a major accomplishment of our first two years of operation. There have been minor slippages here and there in activating a launch stand here or an engine test facility there, but for practical purposes you could say that we met the scheduled target dates that we laid down for ourselves in this over-all facilities program.

Now that the end of it is in sight it looks as though we will not have any slippages because facilities were not available on time. I don't mean to say that everything has been milk and honey, because it hasn't, and we have not gotten as much testing in some areas as we would like because a facility was a little bit late, but it doesn't appear





I happen to disagree with you . . . a national agency for ballistic missiles won't do . . . would be complicated, I think . . .

that we'll be able to blame facilities for any slippage that might occur in the future.

The fourth phase is the operational phase.

WDD is responsible for all four of these phases. We step out of the operation phase at such time when we have an operation capability. When this operation capability has been established the missile is in fact operationally ready, then it reverts to Strategic Air Command control.

Q. *Are you working closely with SAC?*

A. Yes, but the Command jurisdiction rests with me until such time as it is turned over to SAC, which will be some date in the future. Then we would drop out of the operational side of it entirely and revert back to a normal research and development type organization.

Q. *As far as the long-range missiles are concerned, you're carrying out not only the conventional R & D phase but the training of personnel and the production phase of it and even the operational phase of it before SAC takes over?*

A. Right.

Q. *Isn't that unique in the history of ARDC?*

A. It's unique in the history of the Air Force! I think it's very easy to explain why this is the wise thing to do. We are introducing here a type of weapon which required a rather new operational environment. It isn't another airplane that's going to be operating from a standard aircraft base. The manner in which it is going to be operated is considerably different from the manner in which you operate an airplane. The establishment of the actual facilities—the operational facilities—is in itself a development job which is dictated to a very large extent by the characteristics of the weapon to be employed.

You have got to have very, very close tie-in between the characteristics of the weapon and the characteristics of the facilities from which the weapon is going to operate. You have to marry the two. You can't do it any other way. In order to conserve time, this is the main thing that we are trying to do here. The Air Force felt, that by giving one organization the total responsibility for integrating all of these things it wouldn't be necessary to get everybody's blessing and then call in an umpire if there is a disagreement. I personally feel that in this case because of the uniqueness of this weapon, that this type of an approach is sound.

Q. *Could this concept be employed in any R&D program?*

A. I would not recommend this type of organizational approach, say if we were developing a new airplane like the B-58. It's an advanced jet bomber with better performance characteristics, but you're going to introduce it in exactly the same operational environment as other jet bombers. The manner in which you're going to operate that weapon—the command structure; the communication structure—is going to be very similar to the one you used for the B-47 and the B-52 so you shouldn't depart from standard method for the B-58.

Now, I might comment at this point, I've noticed in the past where your magazine has advanced a national agency of some kind to carry on the development of ballistic missiles. I think everybody is entitled to their own opinion on this. I happen to disagree pretty violently with this philosophy simply because of what I've just been talking about—the necessity for a total program being under the direction of a single agency. If you have a separate national agency somewhere developing the hardware, I'm not saying you couldn't get a very fine agency for the development of the hardware. But the problem of introducing this hardware into a military organization where it becomes a useful weapon, I think, would be complicated to a much greater extent than any benefits that you might derive by having a national agency.

I'd even grant you that maybe you could have one that has a better capability and confidence than we have. But I'd still say that it wouldn't be the right thing to do, unless the differences in confidence were so great that there was a question about our ability to get the job done, as against the other agency's certainty of being able to get the job done.

Q. *How about the scope of testing at the Patrick facility? It seems to be getting sort of crowded with the Army, Navy and Air Force all wanting to schedule tests at the same time. Will this interfere with the testing of the long-range missiles?*

A. Well, I don't know if I can really answer that for security reasons but I think I can say this: the Patrick test facility has never really been called upon to accommodate a large-scale test program. All of the testing down there has been sort of on an individual basis. Procedures that apply to that kind of testing would not be very satisfactory to a large-scale test program such as we envision. We have done a lot of studies with Patrick on the streamlining of procedures to accommodate the larger volume of testing, such things as range safety provisions.

Possibilities of a three-shift operation, in other words, working around the clock on a standard three shift operation instead of calling upon an extra crew that might be required from time to time. We have concluded that there doesn't appear to be any reason why we can't accommodate our test program at Patrick. For the expansion of facilities, from our standpoint, I think we see the end of our major facilities requirement on the horizon. And within a relatively short period of time we will have our facilities, except for minor extensions which are always of course to be expected.

Q. *What does the top national priority that the program has been given actually involve?*

A. I think the best way to put it is that it has generated a streamlining of procedures, primarily within Washington, and it has provided contractors with a priority for materials. It also has resulted in the relative rapidity of decisions from the top level, plus support economy-wise as far as the contractors are concerned in getting their materials, parts and components ahead of any other requirements on the list.

It also, of course, resulted in our getting a very high priority in availability of key people—qualified people. It resulted in our being given the funds required to do the job. I would say the funds plus streamlined procedures for decision making are perhaps the two most important results of the national priority. I think it's fair to say that we have been proceeding at the fastest rate that technology permits.

Q. *Ever since 1954, you mean?*

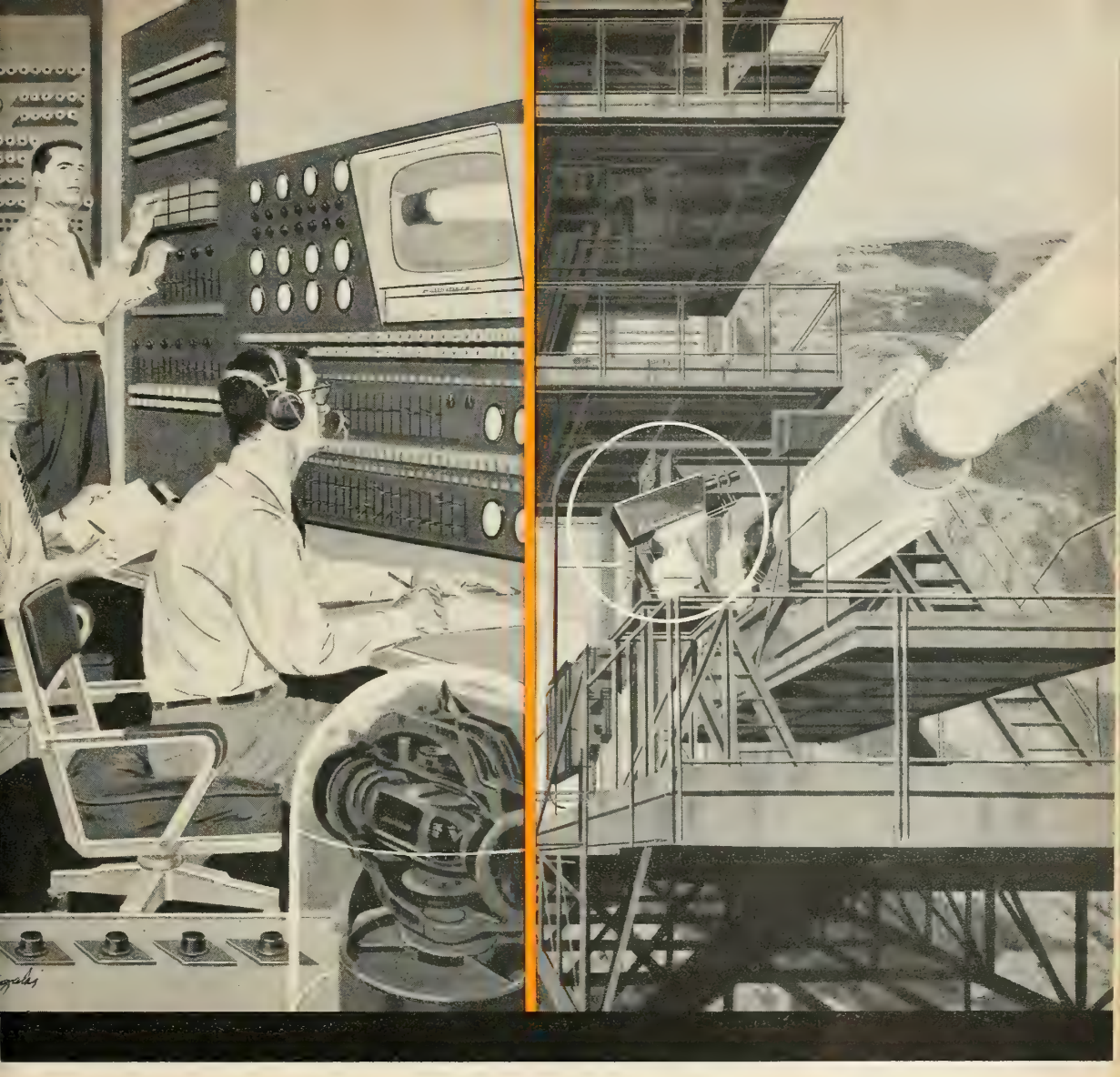
A. Ever since 1954. During the first year or so of the program the fund requirements were such that it did not require that a national look, you might say, at the funds was necessary and we were able with an Air Force priority to meet the needs of the program at that time. But by the time we had hit the middle of '55 the Air Force no longer could swing it on their own. I mean if we had not gotten a national priority about then we could not have carried on the program at the rate we have.

Q. *Are there any other military projects in existence that involve so much support from industry and science as the ballistic missile program?*

A. No.

Q. *Then, this is the biggest project the Air Force has ever attempted?*

A. To the best of my knowledge that's true if you add up the systems, the *Thor,* the *Titan,* and the *Atlas.* As a total the Air Force Ballistic Missile program is the biggest weapons system project we've attempted. I think that's a fair statement.



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The Ballistic Missile Procurement Problem

. . . as seen by Brigadier General Ben I. Funk

Deputy Director of Ballistic Missiles, AMC
Chief of the Ballistic Missiles Office, WDD

Q. *General Funk, you deal with all of the ballistic missile contractors?*

A. Yes, the contractors are as deeply involved as we in this management effort and in the ballistic missile program—more than any other weapon system program that I know of. They have been around AMC for many, many years, and they have been working on other management problems as well. What we're doing here is asking industry very early in the program to begin gathering what we call "failure rate and consumption data" on the components that are tested. In other words, the WDD people in coordination with R-W set up the tests to be followed by the contractor. The contractor begins getting failure. Normally in an R&D program you're not in such a hurry to know instantly which part failed and how many of these are consumed over a period of time. But here again we need to compress time to meet this priority program. We already have a format that we're implementing which will insure that we do get it—and get it when we need it. Now at Convair, they have more work in process, and they are turning out more work than the rest of the contractors on the *Atlas* because they have a systems integration responsibility in addition to the airframe fabrication. On the basis of the information we get from them we can begin the process of provisioning the spares requirements. Provisioning the spares for not only the missiles themselves, but the ground support equipment. It is extremely important in this program.

Q. *Ground support is one of the things that we'd like to know about. We have an idea that you are now pretty deeply involved in the planning of the actual launching facilities.*

A. Well, we are all involved of course in trying to firm up what ground equipment is going to be required, and what levels of spares are going to be required so that we can budget and buy in time. I'm speaking of the lead time requirements to get all the things into Camp Cooke necessary to make it function as a missile training base. We must be thinking now about what ground support equipment and what spares we're going to need.

When we think of spare parts not only do we have the spare parts problems for the missiles themselves, but ground support equipment has to have spare parts. Let me make an anology particularly applicable in this weapon system. With a gun, you of course think of the gun and the bullet. Well, we have a lot of guidance equipment and a lot of support equipment must stand on the ground. Your missile's the bullet, and your gun costs a lot of money, and this is where the uniqueness comes into this program; whereas most ground support equipment percentage-wise, would run, anywhere up to 35% depending upon which weapons system you are talking about.

In this program it may run as high as 50% of the total cost for ground support equipment alone. So you can see the importance of making certain that we are selecting the right kind of ground support equipment and that we're not duplicating anything that is already in the inventory.

Q. *How do you go about implementing your long-range planning objectives?*

A. We visualize the use of electronic data processing means to actually manage all of the assets to support a weapon system. By that I mean we have our common Air Force items; then we have the design procurement items which the contractors themselves are responsible for; certain government furnished equipment and certain contractor furnished equipment. We would use the large computers that industry is now turning out to compute and determine levels that would be required, say at a support base, launch complex or at a contractor's facility. Now, at least initially, we feel that in order to buy time (and this is a phrase we often use here too) we need to have the contractors provide us with the depot level of supply and maintenance for their procurement items. Under our AMC depot system, usually the depots themselves do the whole depot level job to support the weapon system in the field.







In this program we may run as high as 50% for ground equipment . . . we're taking a calculated risk . . . we may make some changes . . .

Here we would bring in the contractors. We've got to contract with him to not only build this weapon, but to support this weapon. We are actually in the initial stages of working this out with the contractors now. This is during the initial operational capability phase that I'm talking about now, and my weapon system manager responsibility would implement that type of a logistics plan.

Q. *How does your job differ from a normal AMC job? Is it normal for AMC to get into the act of producing weapons at this early date, and is it an advantage?*

A. It is not usual for AMC to get into the act of producing weapons at such an early date. Here again though, if you're going to buy this time that we keep talking about, there's no other way to do it than to accomplish the R&D, and production-operational phases on a parallel basis. Obviously, we're taking a calculated risk that maybe we're going to make some major changes. We don't think we will. We think that the necessary changes will be minor. In effect, this is not "business as usual"; this is pioneering. We have to deviate from the old established hand-driven methods, and we do this whenever we feel it buys us time.

Q. *Does your office get involved in choosing personnel for the project, or do you leave that to the contractors?*

A. We provide a surveillance function with the contractor to be sure that he is getting proper quality and quantity of manpower to do the job. If we're dissatisfied with the number of engineers and technicians that he has—for example, if he is late on his engineering work order releases; if he's out of station on his production line based on lack of engineering effort, we're to take action and tell the contractor he needs more qualified engineers or whatever. He gives us a forecast of his manpower buildup by category of manpower, manufacturing, engineering and so forth, and we monitor this very carefully and look at it in a monthly management meeting we have here.

Q. *How do you go about determining contractor specifications on something you've never built?*

A. Well, there are no specifications, in the main, in this program because we're doing something brand new—new fabrication techniques, new types of weapons. So we have to deviate from the normal acceptance procedures for Air Force materiel. Where you'd normally inspect to a certain set of specifications, we don't have them so we have to use our best judgment here as to whether we do or do not accept something.

Q. *What about problems you don't anticipate, such as the contingency factor?*

A. We're realists, let's put it that way. We have had enough experience that we can generally anticipate the areas where we're not going to have difficulty and where major testing is being accomplished. We do a lot of testing on the ground to insure a reasonable degree of certainty that we won't have any delays due to a particular new fabrication technique or new metal or something like that. The degree of reliability required in this program is unique. It's higher than any other weapon system program simply because you launch unmanned missiles, whereas when you launch a bomber if it doesn't work, you just fly back home.

When you launch a missile it's gone. In this business you must build in a very high degree of reliability, and this reliability is not only in the weapon system itself, it's in the systems which stay on the ground and in the ground support equipment. Reliability is here again unique, and it's highly important.

Q. *What about storage? Can you store the missiles for four or five years and then take them out and make them work?*

A. Well, the missiles won't be around for four or five years. Obviously you must have a degree of readiness at all times. I'm not going to go into the degree of readiness because it is classified. But it does require the rotation of operational inventories for example.

Q. *Well, isn't it safe to assume that when you reach the production stage, you will have a certain production output of these missiles at all times, because you will obviously have to launch some of them for training purposes?*

A. Definitely. We're not going to build just so many and then quit!

Q. *You're going to shoot the missiles as part of your crew training program?*

A. Of course, you're absolutely right. So provided a contractor performs well under the contract terms it is reasonable that he would still continue to be in business for some time to come. You not only have this problem of production in the missiles, but here again the ground support equipment and the spares must be programmed for. It's not a one shot deal in any sense of the word, but a continuing program. It's the one thing that I think a lot of people misunderstand.

There is a tremendous amount of planning that has to go into this weapons system to make it a useable programmed weapons system—not only is it a program for the procurement, production, logistics, logistical support, training, base selection, base building, you're also building the installations, you're building communications systems; you're building electronic data processing systems; you're building contractor capability to do supply and maintenance of the weapons, as well as getting an Air Force capability to the degree that it can supplement the manned bomber force.



This is not business as usual, this is pioneering . . . we're not going to build just so many and then quit!

The Ballistic Missile Management Problem

. . . as seen by Dr. Simon Ramo

Vice President, Ramo Wooldridge Corp.

Q. *Dr. Ramo, how are the financial aspects of the ballistic missile program handled?*

A. R-W does not have any connection with monetary phases of the program. No money passes through R-W. We do laboratory work, we simulate the whole system, we do regular dynamic analysis, we do certain kinds of laboratory explorations on any fundamental point that is basic to a decision that has to be made. We supervise the final system tests. We decentralize to the airframe manufacturer what you might call the physical integration and system test operation. We do not attempt for example, to design hardware details.

Q. *What is the size of your staff?*

A. Well, I can't give you the precise number, which is classified, but there are some hundreds of engineers and scientists. These experts are assisted by certain non-technical, administrative, clerical and other help. Our principal group is composed of some forty people, average age 40, who have 15 to 20 years experience, and who are graduates of programs of this general kind. You'll find that many of our key people have associated with other successful complex programs, extending from World War II to missiles of the last ten years to other weapon systems, including Manhattan project assignments.

Q. *Will you expand the GMRD as the program goes along?*

A. Well, the program has not yet hit its peak personnel requirements but it is very close to it. Obviously, we do not anticipate any need for expanding indefinitely. Nor do we plan to ever go into production in this general area of ballistic missiles. This is of course a key point. We have felt it's rather important in taking on the systems engineering work for this project, to be sure that every one of our decisions are based on the most objective thinking possible. Thus we have no production contract and engage in no production in connection with the ICBM program.

Q. *How about the need for more missile engineers for this particular program, say, during the next 15 and 20 years?*

A. Well, of course, what has to be decided is what rate is essential. The number of engineers and scientists that we have will partially determine how fast we go in this highly technical society of ours. Most of the time in connection with most of the things that are happening today, I do not believe that there is a shortage of engineers and scientists. But, rather it's a problem of how we utilize the available scientific personnel.

Q. *We have noted that the locations of the contractors engaged in the Air Force Ballistic Missile Program are spread over the whole country. Does the dispersal aspect of National Defense play any role in this?*

A. It did to some extent during initial stages of the program. It is not easy to talk inquantitative terms as to the decisive step. For example, North American was the major developer and supplier of large rocket engines. And Aerojet was another. We notice that both of those are California companies. And we notice that both of those have had a very great deal of expansion from the standpoint of facilities. We also notice some things, however, in the Mid-West in support of these companies. Convair and Douglas as two airplane companies, are both located in Los Angeles with expansions of their programs and with large systems test support in their areas; such as San Diego and at Edwards Air Force Base. We also notice that while Martin is located in Baltimore, Maryland, it has a division in Denver working on this project. So, you see there is a certain amount of dispersal.

Q. *The Martin Division in Denver was actually set up for this program?*

A. The Division in Denver was set up after they came into this program.

Q. *So it might be safe to assume this move was dictated more by the ICBM program than by the dispersal aspect?*



The number of engineers . . . will partially determine how fast we go in this highly technical society of ours . . .



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A. Well, at any rate, I think this is a conjecture that you yourself have to make. Let me point this out, certainly it is true that companies have been expanding and seeking other locations. In our case, the Denver plant of the Ramo-Wooldridge Corp. is intended for larger scale production than we will do here in Los Angeles. A major reason for our going to Denver was the dispersal policy. However, there are some advantages in our locating ourselves partially out of Los Angeles in any case. Thus we also have offices in Dayton, Washington, D.C., Boston and Cocoa Beach, Florida.

Q. *Did you say R-W was a production facility?*

A. Yes, this applies to our five other divisions but not to the GMRD, which works only on the Ballistic Missile Program.

Q. *What do your other divisions do?*

A. Well, to make it very short and simple, the Ramo-Wooldridge Corporation was set up with a number of divisions emphasizing electronics work; not only the systems engineering aspects of electronics projects but the actual development and production of equipment right through to spares and maintenance. We were engaged in these activities when the Air Force asked us to take on the ICBM systems engineering and technical direction assignment. To do this job we set up our Guided Missile Research Division solely devoted to ICBM. The Guided Missile Research Division is only concerned with systems engineering and technical direction for the Air Force's Ballistic Missile Program. It does not do any production nor will that division do any production on follow-on jobs.

Q. *Does the R-W Denver plant have anything to do with the fact that Martin also has a plant there which is doing ICBM work?*

A. There is no connection whatsoever. As a matter of fact, we had acquired the Denver land before Martin was in the ICBM program.

Q. *But Dr. Ramo, hasn't R-W been involved in aiding the Air Force in selecting companies for the Ballistic Missile Program?*

A. We are involved indirectly in a sense that we propose the R & D plan which tends to define the nature of the needed contractors. The Air Force alone chooses a candidate list. We brief those candidates during the short competition period which is always held by the Air Force. In general, all the contractors have been chosen by competition and by the Air Force. We do evaluations on both their oral presentations and on their written presentations, but only from the technical standpoint, and finally we withdraw and are not part of the final deciding team.

Q. *Do you provide some of the contractors with assistance from your expert engineers and scientists?*

A. Yes, the reason this happens is this: Though we try very hard to decentralize the detail, design and development, things will arise in which the interaction between one part and other parts is the key point of importance and we are in a position to see it most rapidly. It is natural that we try to help when we can. But we don't attempt to, and it would be absurd to imagine that we could try to fix it so that whatever every contractor can do, we also have the capability of doing.

Q. *Do the various contractors have representatives here in Los Angeles?*

A. Some of them do.

Q. *On a permanent basis?*

A. Some of them do and some of them do not. But you must remember that there is a tremendous amount of interaction to technical meetings so if you look at any given time you will find WDD/RW buildings full of contractors' representatives. This makes for excellent inter-communication between RW and all major contractors. Basically, we were a little surprised to see how well it worked out ourselves.

Q. *Is there a good deal of travel involved?*

A. Yes, there is a great deal of travel, but this is unavoidable. There is an attempt to arrange meetings and other communications for efficiency. We have perhaps made advances in communications on large projects. It is a problem—always will be when things have to be large and spread out. We have the best organizations in the country and their top technical management are good at communications. These people are developing unusual skill at this; the teamwork is almost exciting to watch.

Q. *Do you anticipate that in the future you might go to closed circuit television conferences?*

A. Actually the communication of words and numbers is much more important than the communication on a visual channel in our work. So that while I have no doubt that years from today, in setting up a major project that is widespread and of an urgent crash nature, one would probably employ television nationally to an elaborate extent. I don't think we are going to take time off to inject it into our system now.

Q. *Do you consider this responsibility to be a great personal challenge?*

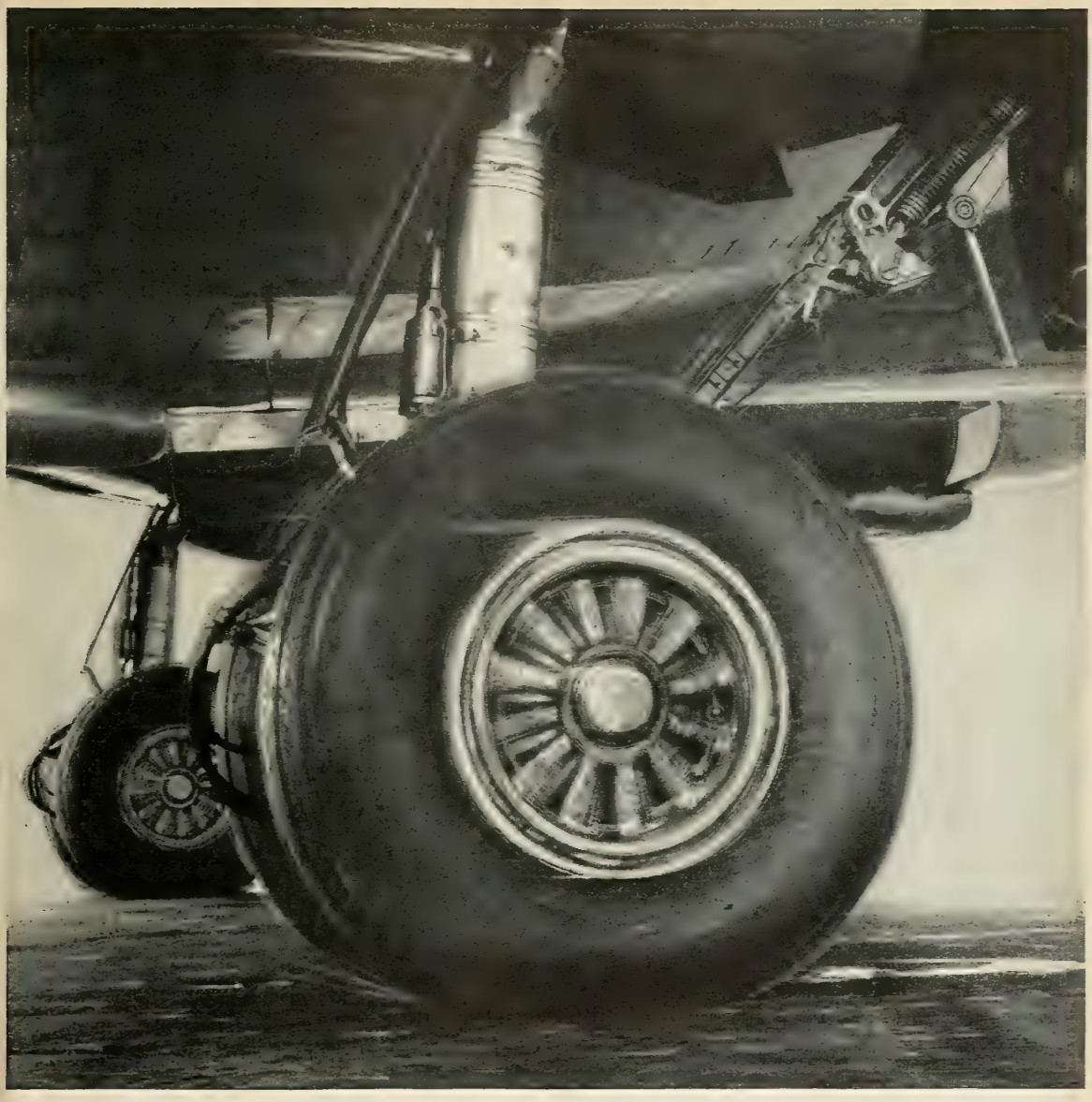
A. You see I feel that we are part of a large team getting a big job done. I would guess in other words that each man in his own way, here and with the various contractors and in the military; each one of them finds what he has to do on the job is a challenge. And each one of them is quite cognizant of the fact that he needs to get his job done or it can be a significant blow to the project.★







...I feel we are part of a large team getting a big job done...get the job done or it can be a very significant blow to the project...



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Astrionics

By Henry P. Steier

SAN FRANCISCO—Fastest growing area for the electronics industry lays within a 100 mile radius of this hilly city. Single level, "California style" buildings for small electronics firms, and for Eastern firms opening branches in the area are being put up at a great rate for leasing. Together with the leased buildings many firms also lease the electronics test gear and machine tools for R&D and manufacturing.

Old established firms in the area like the Hewlett-Packard Co., Eitel-McCullough and Ampex Corp. which are noted for the high quality and flexibility of their manufacturing operations are expanding rapidly. Admirably suited to meet demands on the electronic industry, many firms are planning complete moves of entire facilities to new and bigger buildings or additions to existing ones.

Ampex Instrumentation Division business has jumped from $12 million in fiscal 1955 to $19½ in 1956. Big percentage of tape recorder instrumentation business is in the missile field. Tape systems for aircraft flight evaluation and engine tests have been growing in use, and for missile telemetry uses promises to be even greater.

Operating without any competition in its specific field the company has doubled its personnel in the past year. One reason is new use of Ampex tape systems in hypersonic missiles. Range and radio transmission problems in ICBM test vehicles are being met by recording the data on vehicle-carried tape recorders. Ampex officials will not say how tape is recovered or *if it is.*

One theory is that data is played back during slowest moving part of the missile re-entry flight period. In any event, the firm's laboratories are swarming with ICBM "brass" these days.

•

IRE NATIONAL CONVENTION, 1957—The big show and convention drew 50,000 registrants this year. With 800 exhibitors showing their wares in the New York Coliseum for the first time everyone agreed it was the most pleasant, informative and comfortable show ever.

Everything was new, from the booth displays to the people manning them. Especially noticed was the high technical competence of company personnel who answered questions about the companies' products. Complaints, mounting over past years, that booth personnel were apparently only there to guard the booths were not heard.

Something else new was a complete morning and afternoon session on astrionics. Recognizing the new problems being faced in telemetry and remote control for long range missiles, and space ships a symposium on this subject was a feature of the Convention. The other session was a symposium on techniques for data acquisition and handling in the missile field which emphasized that newest hope for rapid missile data handling-digital systems.

Latest look in booth displays was RCA's calm-looking reflection pool around one corner of the display. The pool soon turned into a "wishing well." Passing engineers soon had the bottom of the pool covered with shiny copper pennies tossed in for who knows why. One joker, however, had tossed in a General Electric Co. medallion which looked like a silver dollar at first glance.

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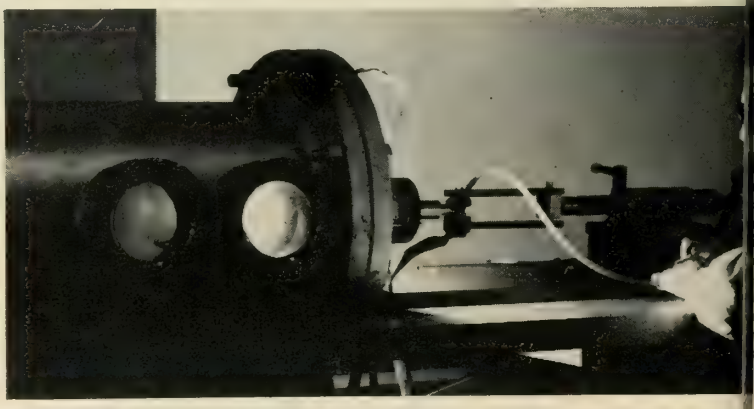
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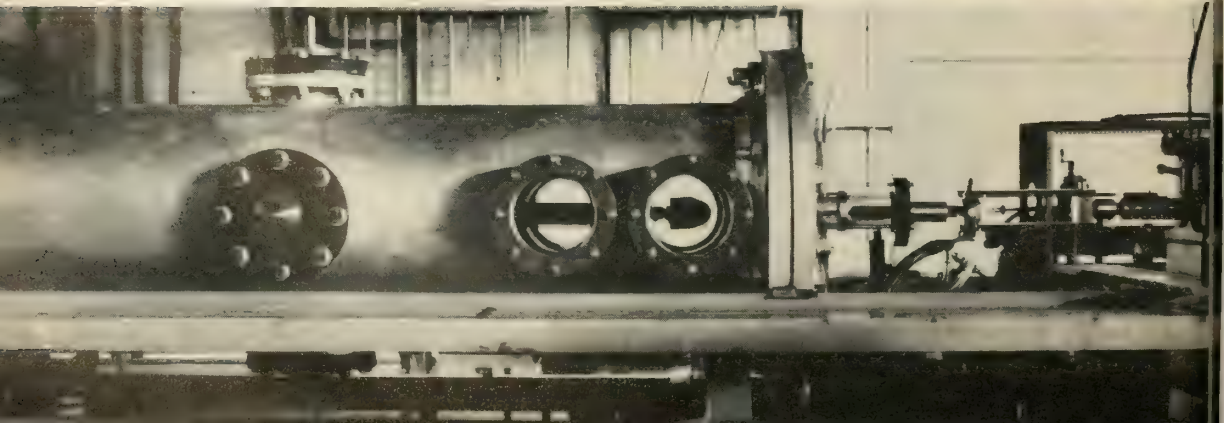
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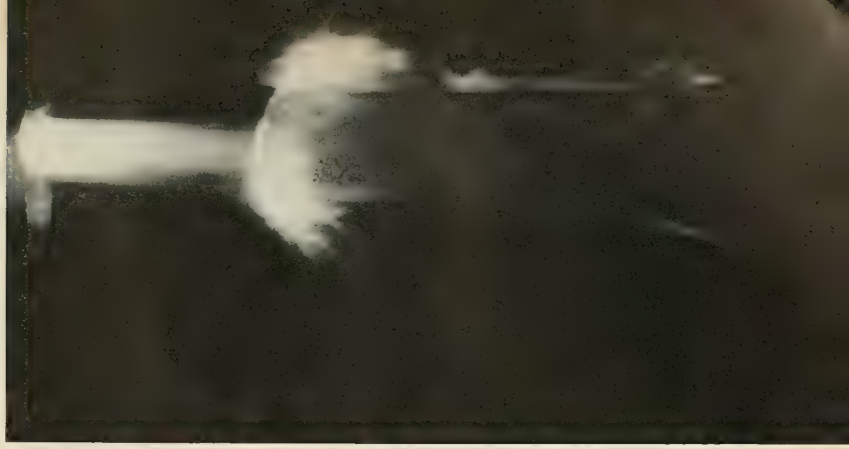
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To Put the Sun to Shad

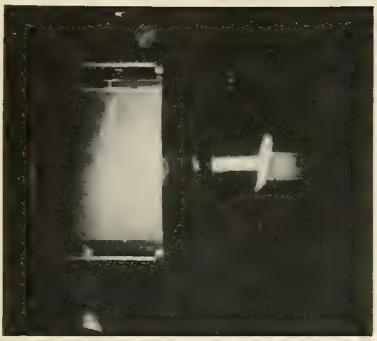
The melting, spalling test cone above provides a vivid demonstration of the problem of high-speed reentry into the earth's atmosphere. Operating in vacuum chamber this water stabilized arc produces a flow of atomic vapor with temperatures exceeding those of the sun's surface. Developed jointly by General Electric Company's Missiles and Ordnance Systems Department and the University of Chicago, this unit using a one-quarter-inch graphite electrode is at MOSD's Philadelphia Aerophysics Laboratory. Below, a medium drag-to-weight ratio nose cone is ready for test. Note equipment's small size, simplicity.

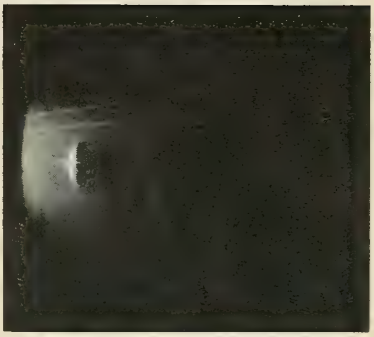




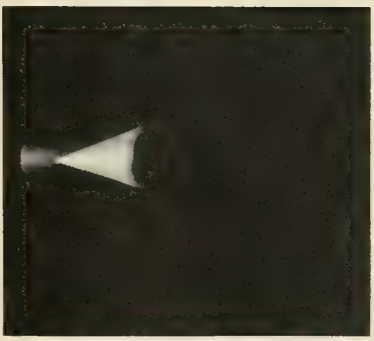


o the right are a variety of test shapes and aterials under test. With the exception of vo in the block of four (pointed cone and oolie hat) all of the runs on this page are air. Notice the tendency to burn as well as elt, sublime and spall. This unit is powered y four electric welding arc generators shown the picture immediately below. Larger units ow being built will produce temperatures of 0,000°K, and will require 10,000 volts d.c.



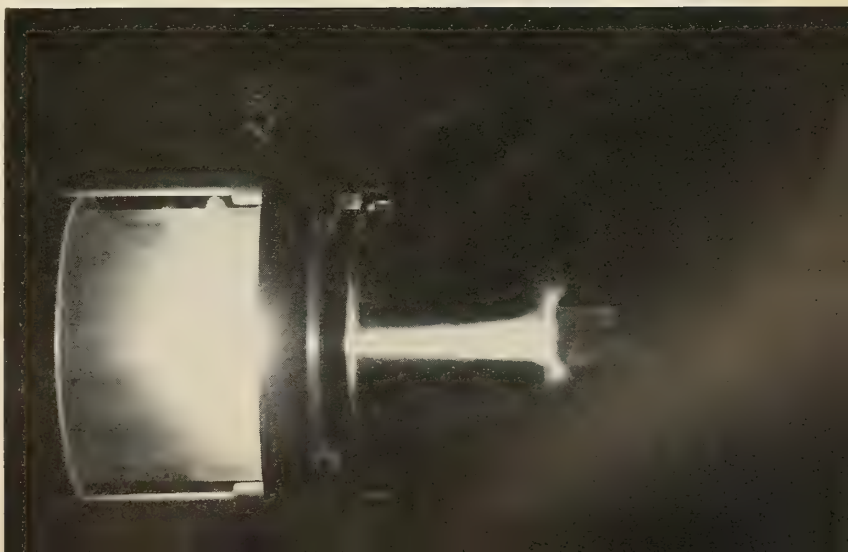




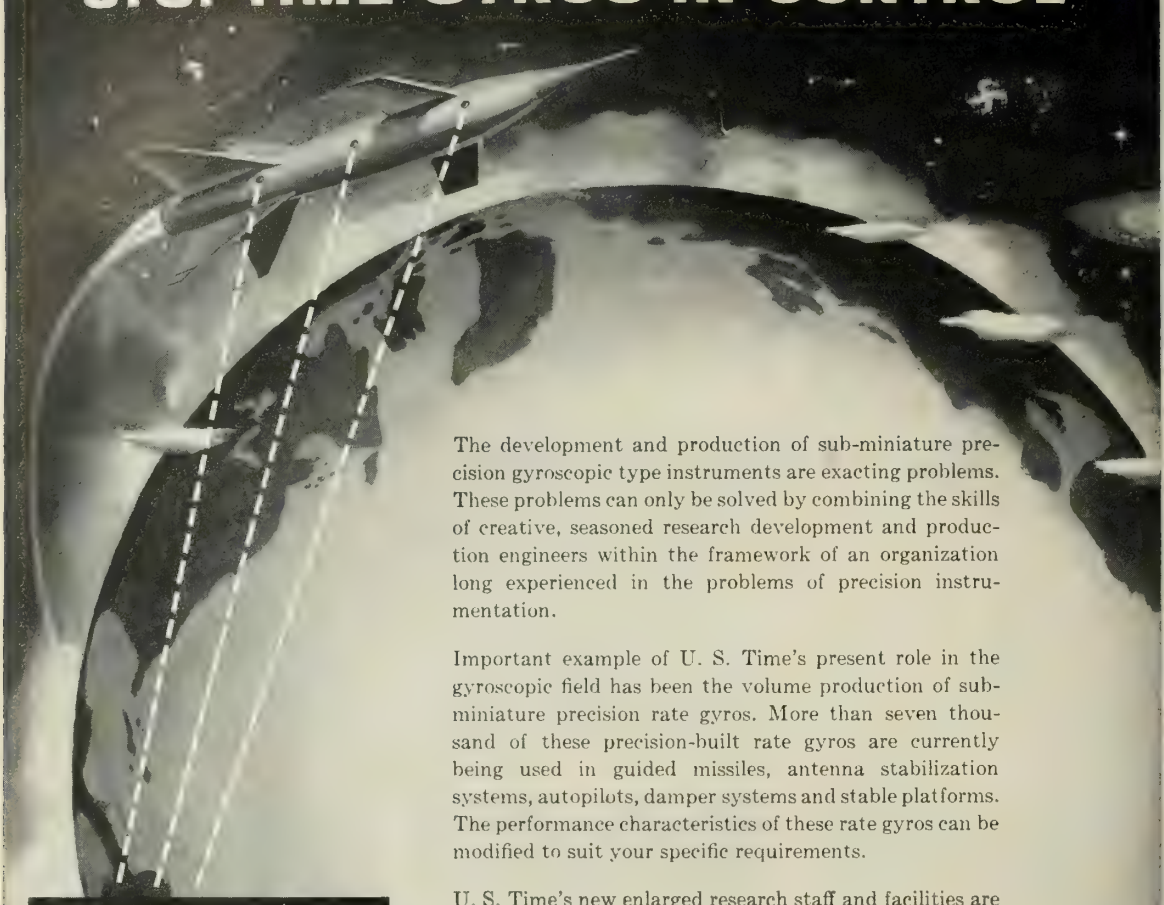




ne photograph at the bottom right of this age shows MOSD's water stabilized arc, or lasma jet as it's sometimes called, at about alf its actual size. A major advantage of is equipment is that testing conditions can e maintained for several minutes consecuvely. Heating rates from 2000 to 6000 BTU er square foot per second have been atained with much higher rates in prospect. or further information see Aerophysics, this sue, and the news section of m/r for March.

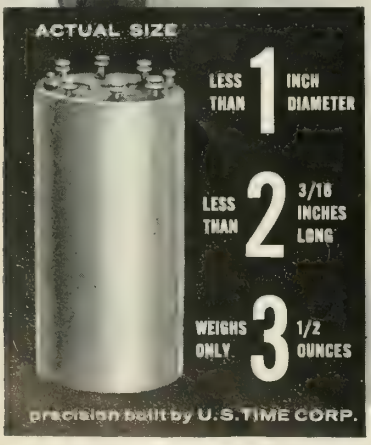


U. S. TIME GYROS IN CONTROL



The development and production of sub-miniature precision gyroscopic type instruments are exacting problems. These problems can only be solved by combining the skills of creative, seasoned research development and production engineers within the framework of an organization long experienced in the problems of precision instrumentation.

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Aerophysics

By Seabrook Hull

A new science—heliodynamics—may result from tools now being developed for studying ICBM heat transfer rates.

Within 12 months so-called plasma jets will be in operation capable of producing temperatures on the order of 50,000°K and stream flow velocities of Mach 15 and up. Inherent in these devices will be heat transfer rates in the range of 10,000 BTU per square foot per second and an ionized gaseous environment "seen" heretofore only through celestial spectrographic analysis. The equivalent black body surface temperature of the sun is about 6,000°K, 50,000°K would be found 600 miles below the sun's surface.

ICBM reentry ballpark figures are 6,500°K and 1,000-to-3,000 BTU, depending on nose cone design and construction. On the same dependence, reentry speeds range up and down from Mach 20.

Both Giannini Research Laboratory and GE's Missiles and Ordnance Systems Department, in cooperation with the University of Chicago have recently announced successful plasma jets. Using relatively small electrodes and "moderate" power sources, temperatures over 14,000°K and heating rates of 6,000 BTU have been achieved. Flow rates have ranged from subsonic to moderately supersonic. In both cases, arcs have been water stabilized.

MOSD, however, plans to complete construction by year's end of a 10,000 Kw arc using a three-inch electrode. Plans are also under way to use liquid air stabilization. Extreme temperatures and flow rates are anticipated. In addition liquid air, when vaporized and ionized by the arc into a plasma, will more closely duplicate actual reentry environment. The 10-to-15% carbon vapor concentration that results from electrode disintegration is not considered to be particularly troublesome.

The plasma jet is still a little-known device. One problem is how to reduce temperature without cutting Mach No. Others involve selection of components to withstand temperatures for protracted running times—several minutes. In one case a graphite electrode drooped; the brass fitting dripped away. These problems, however, are not considered troublesome since peak temperatures occur at the nozzle or beyond.

Similarly, plasma jet potentials have only been suggested. Consisting of charged particles they can be affected by magnetic and electric fields. A study plan is under way to appraise it as the driver section of a hypersonic wind tunnel. Its real benefit, however, may lay in its yet-to-be-developed usefulness in the basic study of matter. In part it duplicates conditions within the sun, results in material states, such as $C_3 7$, never before found on earth. As a basic research tool its redevelopment at this time amounts to a major technological break-through.

•

For aerodynamic study of ICBM reentry problems, GE-MOSD has constructed an expansion throat at the end of the six-inch shock tube at its Philadelphia Aerophysics Laboratory. This device will permit study and optical observation under what amounts to full-scale conditions—with large enough models that the scale effect of the atmosphere no longer need be taken into account.

A check of the state of the reentry nose cone art reveals: (a) it's still highly classified; (b) research may be producing as much new confusion as new answers and (c) though there's still a lot to be desired, it won't be the nose cone that holds up production of operational ballistic missiles. One problem is that some materials that show promise in one test device, pack in in another. Thus the usefulness of plastics, for example, still remains somewhat in doubt. Another problem appears to be how to prevent the reentering warhead from tumbling. Meanwhile, current designs still heavily favor the high drag-to-weight ratio concept.

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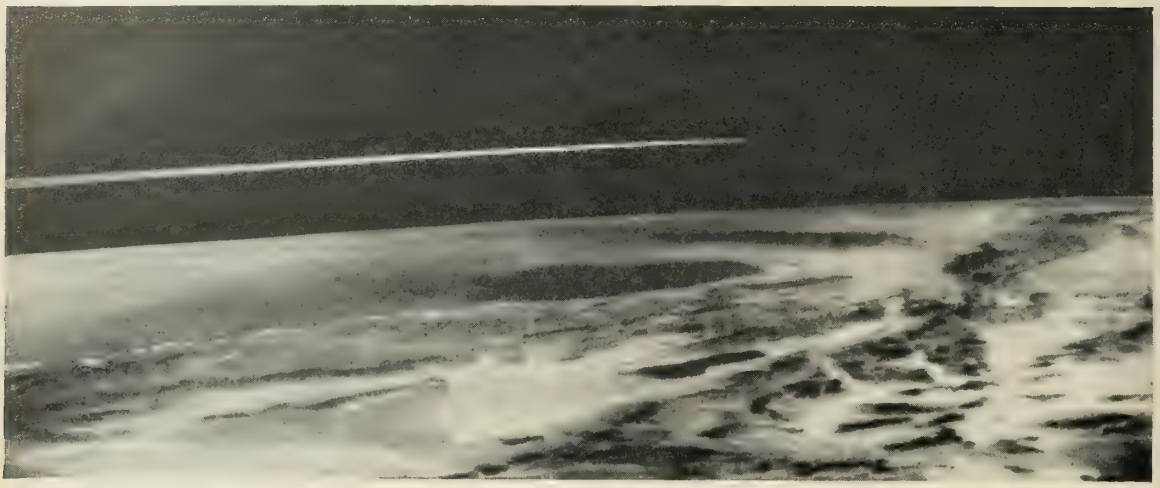
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Career News for Engineers!

Flight Tests are under way on one of America's most important defense projects:

The Navaho Strategic Missile



Artwork based on Official U S Navy Photograph

The results are secret—but this much can be told. A test vehicle designated the X-10 has gathered new aerodynamic and electronic information which will help to speed progress on the SM-64 Intercontinental Strategic Guided Missile.

The opportunity—and the privilege—to implement this revolutionary data is yours.



Twenty-eight-year-old Army vet **WILLIAM T. SCHLEICH** was graduated from Georgia Tech in 1952 with a BSAE. He joined North American as a junior engineer the same year. Seven months later Bill was promoted to aerodynamics engineer for the Navaho missile program. He was appointed Supervisor, Stability and Control Unit in October of last year. With the help of North American's Educational Refund Plan, he received his MSAE from USC. Bill and his wife are hi-fi enthusiasts and have a sound system built into their Whittier, California home.

If you accept this challenge you'll be solving tomorrow's problems—today. Here facts are collected fresh daily. If yesterday's yield proves inconclusive you'll approach the problem from a new direction. You'll travel new paths and develop new inventiveness. And you'll be guided to each breakthrough by the world's best-informed missile authorities—your own associates.

One example of the new hardware evolving from this creative engineering effort is a fully transistorized electronic commutator. This instrument increases the information-relaying capabilities of the missile's telemetering system by commutating 27 outputs at speeds of approximately 100 cycles per second. It was developed by the Flight Test Instrumentation Group.

North American's Missile Development Division is a major center of missile activity—and a pioneer in the field. As far back as 1948 its first test instrument vehicle was fired from a launching platform. Today North American has complete weapons system responsibility for the Navaho—and its test program is being conducted at the Air Force's long-range missile proving ground which stretches more than 5000 miles across the Caribbean and far into the South Atlantic.



LYLE C. BJORN has lived aviation all of his life. As a high school boy he built a glider modeled after the Wright Bros.' first flying machine—flew it from ski jumps near his Utah home. He studied engineering at Utah State and earned his BSME degree from the U of Wyoming. Lyle joined North American in 1951 and is now Group Leader, Field Test Operations at the Missile Test Facility, Patrick Air Force Base, Florida. He lives with his wife and three children near Cape Canaveral where he is an active leader in Cub Scouts.

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A Boom Town Bursts Its Seams

. . . nothing adequate but bars and jobs in COCOA

by Don MacDonald

WHEN THE DEFENSE Department in 1947 chose to reactivate a dormant Naval air station now known as Patrick Air Force Base for potential use as a guided missile test center, it displayed excellent geographical logic. There was no better spot on Florida's East coast from which to pepper the Atlantic with untried rockets sure to be occasionally erratic.

However, as was true so often during World War II, military practicality overshadowed the inevitable need for housing thousands of scientists, engineers, technicians, and their families recruited for the program. The result, 10 years later, is Alamogordo number two—a bleak little boom city called Cocoa.

The initiative of its grocer founder, a man named Willard, can be judged from the fact that when postal authorities in 1822 rejected his first choice of names—Indian River City—as too long, he glanced around his shop, spotted a case of newly arrived beverage, and so the town was born.

Until the advent of Patrick, Mr. Willard's inertia carried through to his descendants. Even judged by Florida standards where a potential alligator farm can be sold for $500 an acre, Cocoa could not claim its fair share of tourists or retired folk, much less entrepreneurs who could contribute more solidly to the area's economy. Major private industry was and still is citrus farming, although breeding Brahman cattle—which thrive where other types fail—is fast becoming a local specialty.

None of this is Cocoa's fault as such. The scenery is like any other part of East coast Florida—flat, palmetto-studded sand, moss-hung live oak, and an occasional palm. The beach is one of the best for swimming. Fishing, especially for salt water trout, is tops. Being roughly at Florida's coastal midpoint, Cocoa's climate is never too hot, and seldom chilly. January averages a comfortable 62 while August is shirt-sleeve moderate at 82 degrees.

As all m/r readers know, jobs go begging in Cocoa. Any engineer who can define ICBM just about has his choice of the Air Force or the numerous aircraft and components manufacturers of the area. Pay scales for scientists, engineers, and technicians are well above normal Florida levels in non-critical industries, just as they are for the trades. Permanent residents within a 100-mile radius complain that no one will fix their leaky faucets nowadays—all the plumbers went to Cocoa.

Anyone accepting a Cocoa job should insist on per diem payments until he settles his family. Typical arrangement now being offered by major employers includes seven cents per car mile from point of hiring plus $7.50 per travel day (350 miles) for the employee, $5.00 for his wife, and $3.50 for each child. Upon arrival, the daily payments are continued up to a usual maximum of 30 days, during which period the employee is supposed to be hunting for permanent housing.

Local motels are well aware of this scale. One newcomer interviewed reported paying $93 a week for a one-bedroom and kitchenette unit to temporarily put a clean but certainly not AAA rated roof over the heads of his small family. Another older hand stated that if he had it to do over again, he would insist on an expense account covering the cost of feeding and sheltering his family over and above a deductible $200 per month. "This," he snapped, "should continue indefinitely until a family finds acceptable perma-

Waterfront development is one of many planned by Gus C. Edwards, local real estate mogul. This picture, taken in February 1957, does not indicate much progress towards solving Greater Cocoa's housing problem.







Enlightened solution by Convair benefits only its own employees, will ultimately give 350 families waterfront homes on easy payments.



New Central Brevard National Bank, locally built and capitalized, is one of few signs of Cocoa's sense of industrial responsibility.



Whimsical sign marks offices of the Greater Cocoa Chamber of Commerce. Newcomers would like less whimsy and more action.

nent housing at a cost bearing some logical relationship to its income."

"We've been here nearly a year," he continued, "and look at this place I had to rush into buying!" He pointed to his nondescript three-bedroom home standing in a row of dozens like it and went on: "It isn't even CBS [stands for 'cement block stuccoed,' a kind of construction unpopular with Florida's voracious termites], the lumber is green, and nothing fits. It cost me twice the $7,000 I could duplicate it for in Oklahoma City."

The most unfortunate Cocoites are those who must rent. If anything is available, which is not usually the case, a minimum rental for the home described above would be $150 per month without utilities or furniture.

Surprisingly, some of the worst gougers can be found in the ranks of fellow employees. Those who had been through the experience of Alamogordo and the like saved their money, came to Cocoa, purchased at least a duplex and in some cases a whole block of homes, and now make more money as spare time realtors than at rocketry.

The Daytona Beach News Journal, 80 miles up the coast, recently featured a series of interviews between one of its newshens and would-be Cocoa residents temporarily lodged in 36-inch conduits, thousands of which line the roads waiting to be installed as part of a new $7 million water system for the area. She found these people reluctant to respond to her questions in a civil manner, and unfortunately portrayed their plight as typical of the housing situation.

m/r's correspondent inspected many such pipes and could locate no one inside. Whether or not they had ever been occupied by humans is no true measure of the area's problem and how natives as well as newcomers are banding together to meet it.

There are those who claim that finding a house is easy compared to driving into Cocoa for Saturday morning's shopping. All traffic from the peninsulas funnels into a two-lane causeway, not even adequate in 1950 when the area's permanent population was 12,000. Now it is triple that.

All businesses except the numerous bars are geared to the past, although the inconvenience of trading with the local merchants is greatly softened by generally low prices for staple items. The one unfortunate exception is groceries. Chain super markets have, up until now, found land too expensive to move in in force.

The crowded condition, reminding transplanted New Yorkers of Macy's Basement on bargain day, is typified by the lone bank whose patrons have trouble finding elbow room in which to fill out their deposit slips. Fortunately, a new and more spacious bank has just opened.

No group in Cocoa is more aware of these detriments to happy living than the city fathers, led by Mayor Garry Bennett, an affable fish merchant and long-time resident. Bennett says: "Good housing and better business facilities are going up just as fast as local capital can provide the wherewithal. Greater Cocoa today is no different than any other boom area."

Bennett points proudly to his newly opened Central Brevard National Bank, an all-new institution located on land reclaimed from the inland waterway and fronted by a highway cloverleaf that will do much to relieve the congestion of traffic pouring into town from the peninsulas.

He cites the newly awakened social consciences of industries in the area. Convair, for example, has purchased waterfront property for an employee housing development that will ultimately take 350 families off the private real estate market by offering them fairly priced dwellings and even spreading the small down payment out in a company-carried second mortgage. Fairchild is planning a similar venture, and others will undoubtedly follow suit. On-base military housing for Patrick is already considered adequate.

Bennett has a right to point to a bright future. Even local entrepreneurs, such as Gus C. Edwards, are finally waking up and hocking their souls to put up decent dwellings to ease the strain as well as turn a legitimate profit. Building permits taken out in Cocoa alone jumped 10 times in value in the last two years. Somewhere in this number will be more and better places to live.

It could fairly be asked that since Patrick is not new, especially when time is measured at rocket pace, why hasn't something been done before? The answer lays partly in local inertia but mostly on the shoulders of the Defense Department, which has a habit of moving into peaceful backwaters and deserts around the globe without planning beyond its immediate needs. When satellite civilian industry follows, housing and attendant problems inevitably develop.

Their solution is too large and immediate a job to be practical for private capital. Cocoa could have long since been an oasis for its dedicated newcomers if Uncle Sam had seen fit to exchange just one B-52 for cinder block and stucco. ★

For a Hot Return

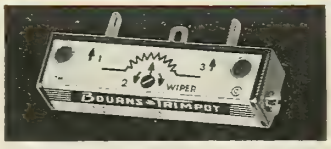


Three-stage reentry test vehicle as it leaves launching rail at NACA's Wallops Island, Va. First stage is an HONEST JOHN while second stage is a NIKE booster—both proven components and NACA favorites in high-rate heating studies. The missile's third stage is a solid propellant T-40 and is programmed to fire in a downward direction. Note the extreme low-drag-to-weight ratio configuration. This cone would be useful in studying the heating gradient back along the missile body, as when, for example, disassociation occurs at the vertex of the cone and reassociation near the tail.

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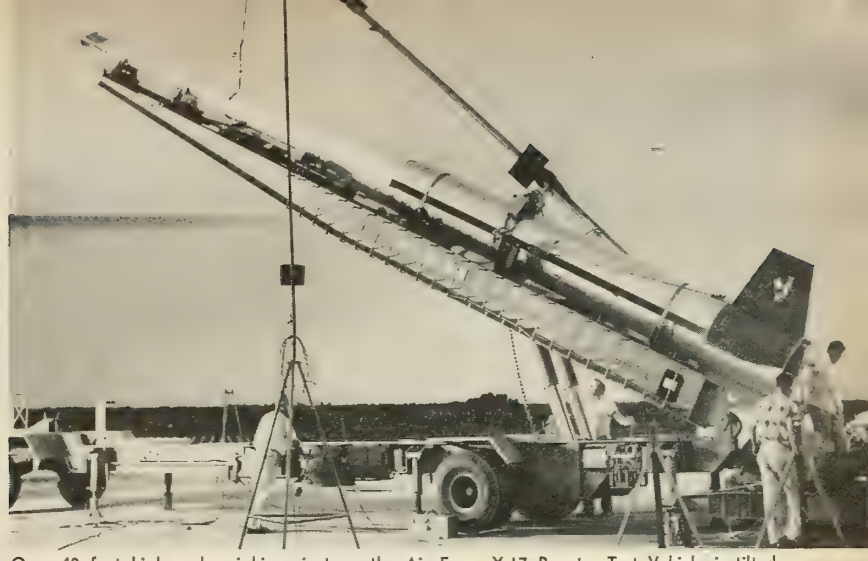
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Lockheed Aircraft Corp's. X-17 test vehicle cuts a grotesque figure in the still, moist predawn Florida air as it's readied for firing from Patrick Air Force Base's Cape Canaveral launching site. The job of the X-17 has been to approximate long-range ballistic missile reentry conditions. Velocities on the order of Mach 15 are accomplished by firing the final stage in a downward direction. Data thus gained will contribute to development by Lockheed of the Navy's Fleet Ballistic Missile, POLARIS, as well as to the Air Force's two ICBM projects.

Consisting of a modified SERGEANT first stage, three encased RECRUITS as a second stage and a single RECRUIT third stage, the X-17 from a propulsion viewpoint is a Thiokol product.







Over 40 feet high and weighing six tons, the Air Force X-17 Reentry Test Vehicle is tilted into firing position by a device nicknamed "strongback." Note the telemetry tower and antenna in the foreground. Ideally, the X-17 is fired in such a way that its third stage hits the Atlantic while over the continental shelf, enabling the test nose cone to be recovered.

The Spectacular X-17







The spin stabilizers fire for only a brief moment before they burn out and are flung free (see picture to far right). The X-17 test program is being conducted by Lockheed as part of the Air Force ballistic missile program under the supervision of the Air Research and Development Command's Western Development Division. The knowhow cannot but be helpful in working with the General Electric Co's. Missiles and Ordnance Systems Department to whom Lockheed has given a contract for POLARIS nose cone development.

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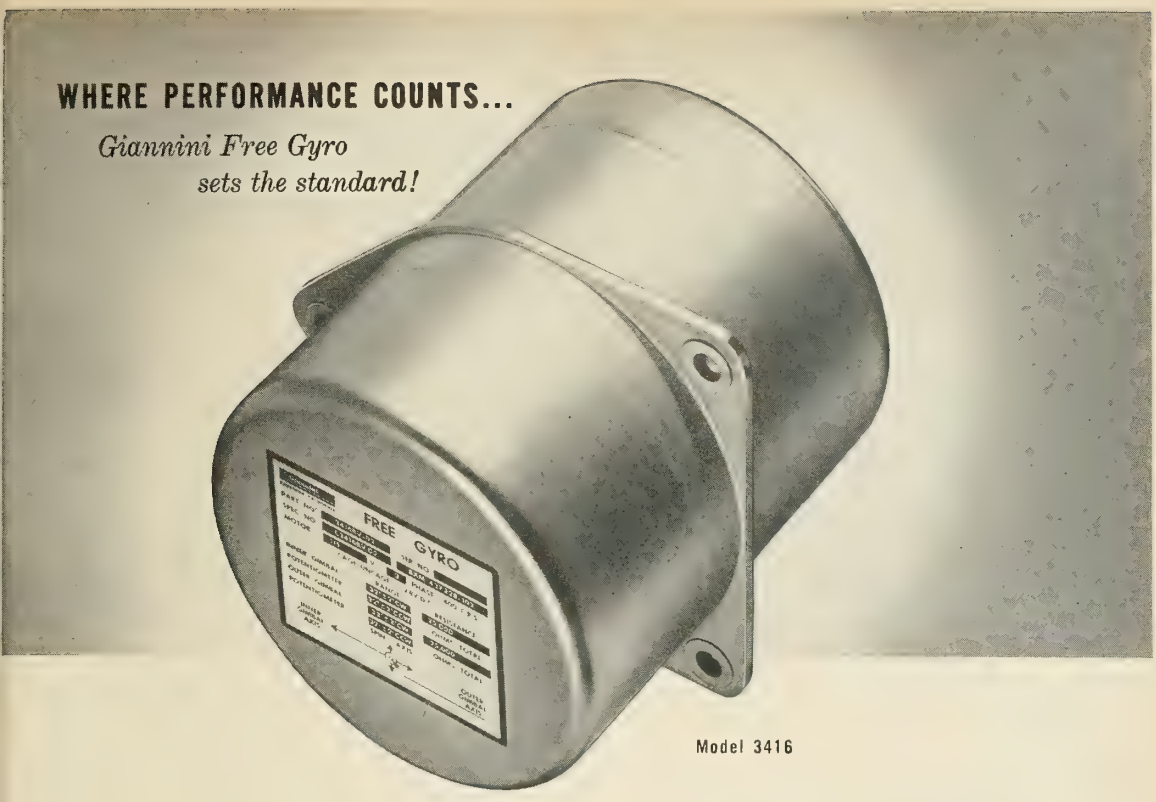


Carefully protected from the weather by a polythene bag, a blunt high-drag-to-weight ratio nose cone awaits launching for 8000 mph reentry test. This rocket test vehicle consisting of an HONEST JOHN first stage, NIKE booster second and third stages, RECRUIT fourth stage and a Thiokol T-55 fifth stage is the latest of NACA's hypersonic reentry rockets. It is shown about to be launched from NACA's Pilotless Aircraft Research Station, Wallops Island, Va. The vehicle attains its record speed by firing the last three stages after the rocket has "gone over the top." In previous similar work, an NACA four-stage rocket attained a speed of Mach 10.4 (6864 mph) and an altitude of almost 200 miles. The speed of this five-stage vehicle has never been officially announced. Aside from telemetered data, the missile's performance is monitored by visual, electronic and special photographic aids. From the first through the fifth, companies responsible for the various stages include Douglas Aircraft and Emerson Electric (HONEST JOHN); Ingersoll Div., Borg-Warner Corp. and Goodyear Aircraft (NIKE boosters); and Thiokol (RECRUIT and T-55).



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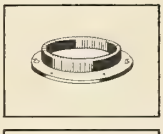
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The Johns Hopkins University
APPLIED PHYSICS LABORATORY
8643 Georgia Avenue
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Propulsion Notes

By Alfred J. Zaehringer

Ionization as the result of the combustion of fuels at simulated altitudes in oxygen was studied by the Naval Research Lab. At an instrument frequency of 24 x 10^6 no attenuation was found for hydrogen sulfide, carbon disulfide, or hydrogen. Ionized fractions: about 10^{-4} for acetylene, ethanol, and gasoline; and 10^{-5} for ammonia. These figures were about 6 times greater than predicted.

Aerojet has been granted a patent (US 2,771,739) for suspensions of lithium, beryllium, boron, aluminum, magnesium, phosphorous, potassium, or sodium in liquid hydrocarbons such as gasoline. Oxidants are WFNA and RFNA. Use is for hypergolic bipropellant rocket systems.

Burning rates of solid propellants are said to be increased 100-200% by addition of hydroxylamine perchlorate in a new patent (US 2,768,874). The crystalline compound is hygroscopic, decomposes at 120°C, and can be initiated by impact of a 2 kg weight falling 15 cm.

NACA has released its findings of research on nitric acid systems. Lewis Flight Propulsion Lab has found that RFNA with 19% N_2O_4 and 3% water gave the best low freezing point and short ignition delays. Some 17 acids were tested. Triethylamine made for the best blend of aromatic fuels down to —76°F. At lower temperatures, 30% ortho-toluidine in triethylamine gave the shortest ignition delay with RFNA. In general, it was found that ignition delay decreased with increased oxygen content and decreased with temperature increase.

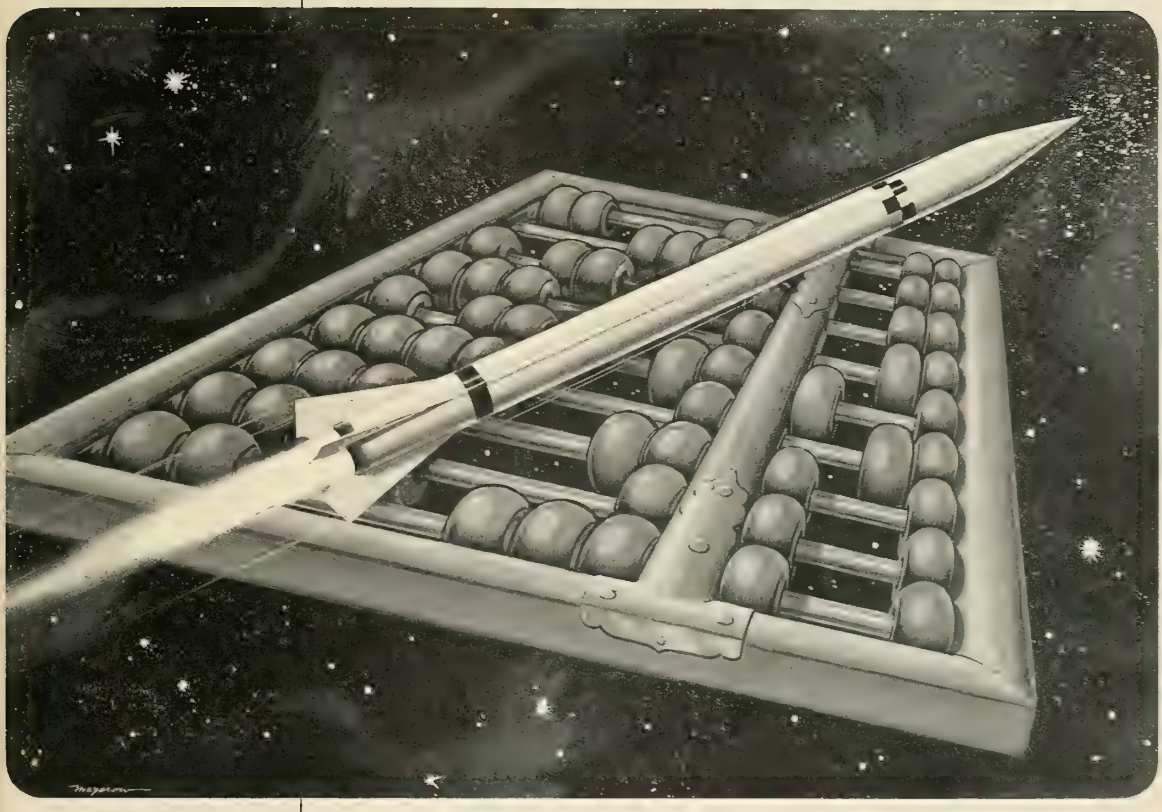
High energy Aeroplex solid propellant (Aerojet) has an exponent of burning rate only slightly greater than ammonium nitrate-base propellant. Typical burning rates (in/sec) over a chamber pressure range of 500-2,000 psia: ammonium perchlorate, 0.6-1.4; potassium perchlorate, 0.4-1.2; mixed ammonium nitrate and ammonium perchlorate, 0.1-0.18; ammonium nitrate, 0.04-0.08. Aerojet also reports a "medium energy" ammonium perchlorate propellant that plateaus at about 0.3 in/sec. The burning rate is constant from 1,000-2,000 psia.

Hydrogenation of unsaturated polycyclic hydrocarbons gives jet fuels with higher heats of combustion than conventional fuels (US 2,765,617). Monsanto claims a typical heat of combustion of 136,800 BTU/gal.

Patents were granted to Phillips Petroleum for fuels in liquid propellant systems. Piperidine and substituted piperidines are claimed to be hypergolic with acids, peroxide, nitrogen tetroxide, oxygen, or ozone (US 2,771,737). Another (US 2,769,304) is concerned with hypergolic fuels of low freezing point and short ignition delay. The fuels are composed of 10-87% volume pyrrole and 13-90% volume of ethylenimine and other oxidizers. Combustion stabilizers are chlorides and naphthenates of iron, zinc, or cobalt.

Sign of the times: Olin Mathieson made its first tank car shipment of hydrazine recently from its Lake Charles, La. plant. Commercially available since 1953, deliveries have all been in small lots.

American Rocket Co. is entering the liquid propellant field with the introduction of a new-type, high-energy monopropellant. It is a liquid with very low freezing point and high boiling point. Other features: very high density, ease in handling, low cost. The new material has been under development since late 1956.



Computers for Missile Guidance

The Jet Propulsion Laboratory is a stable research and development center located north of Pasadena in the foothills of the San Gabriel mountains. Covering an 80 acre area and employing 1700 people, it is close to attractive residential areas.

The Laboratory is staffed by the California Institute of Technology and develops its many projects in basic research under contract with the U.S. Government.

Opportunities open to qualified engineers of U.S. citizenship. Inquiries now invited.

The abacus is a very ancient and useful computing device in the hands of a person versed in its use. However, the requirements for speed and accuracy in computing the functions necessary for modern missile guidance have obsoleted all man-operated devices, creating a need for computing systems previously considered impossible.

The Jet Propulsion Laboratory pioneered in the application of analog computing techniques to missile guidance systems and, to maintain its leadership in this field, constantly searches for new techniques that will make optimum use of magnetics, transistors and other modern computing components.

The successful application of these techniques to missile systems under development requires designs that will perform properly under the adverse environments found in today's guided missile. A degree of accuracy and extreme reliability, previously thought possible only under controlled laboratory conditions, is now a reality because of improved instrumentation techniques and development of highly accurate instrumentation equipment. This has been successfully applied to development of special purpose equipment for missile guidance.

The JPL guidance computer group, now engaged in research and development work encompassing electronic, mechanical, electromechanical and servo computing systems and their application to missile guidance and control, now offers attractive opportunities for truly creative engineers interested in advancing the state of computer art.

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Moving Averages Police Solid Rocket Output

At Air Force Plant 66, McGregor, Texas, Phillips Petroleum Company, through its Rocket Fuels Division, is engaged in the development and manufacture of solid propellant rockets of various kinds and sizes. Several rocket types are nearing the qualification stage. The M15 has progressed through the stages of laboratory experimentation, pilot plant production, and qualification, and is now in large scale manufacture for service use. This unit is powered by a rubber-base, extruded, solid propellant grain.

Statistically sound sampling plans are in use for the acceptance of incoming chemicals and metal parts. A relatively small variation in a chemical material from specifications may result in either expensive difficulties in processing or rejection of propellant. A change of source in certain materials may require process alterations. Quality control in processing is equally essential since even such variations as mixer-to-mixer differences in intensity of mixing must be considered. Wherever sampling or testing is expensive or destructive, inspection by variables rather than by attributes plans reduces cost.

Attributes inspection is, of course, inspection for the presence or absence of a certain characteristic or attribute.

Variables inspection is the actual measurement and recording of a quantitative value, such as 2.93 inches. This inspection yields data telling not simply whether a dimension or quantitative characteristic is within specification, but also how far it is inside or outside of the specified limits. Equal assurance can be attained with a much smaller sample through the use of variables sampling plans than through the use of attributes plans.

For ballistic acceptance of the M15 JATO, consideration was first given to lot-by-lot acceptance using variables sampling plans. A lot, for purposes of this paper, is a group of consecutively manufactured rockets produced under the same set of processing procedures from materials having no significant changes affecting end performance. Such a lot may be considered as homogeneous in nature, with no abnormal variations in any performance characteristic from the lot average for that characteristic. Ordinary lot acceptance would require that each lot be completely manufactured prior to selection of random samples to be fired. This requirement led to one of two alternatives:

Either lots had to be kept to a minimum size (100 to 300 JATO units), to allow for minimum storage and delay prior to acceptance, with the disadvantage that variables sampling would lose much of its sensitivity and require more destructive testing, or larger lot sizes and more storage were required. Disadvantages would be the cost of storage facilities and the increase in delay in information from acceptance firings.

Neither alternative was very satisfactory. After a study of the problem, it was decided that maximum sensitivity to trend changes in ballistic parameters, greatest economy, and minimum delay of information to manufacturing personnel could be achieved by adapting a variables fractional continuous sampling plan for ballistic parameters, as explained in the following paragraphs. The basis for this type of sampling plan was presented by Harry G. Romig in a paper entitled "New Statistical Approaches in Aviation and Allied Fields," presented at the Aircraft Quality Control Conference at Dayton, Ohio, in November, 1953.

The plan as adapted for M15 JATO calls for a lot to be one month's production, unless some change in the process occurs requiring a change of lot designation. For acceptance and identification purposes, a one-month production lot is broken into sublots representing the production of one eight-hour shift. Ballistic acceptance sample units are chosen from these sublots. Every precaution is taken to insure a completely random choice. Control is maintained of the calibration of the instruments and test equipment used in firing the sample units, and of the conditioning temperature of the units prior to firing.

Acceptance sampling is carried out on a fractional continuous basis through the use of a three-point moving average for each ballistic parameter. In other words, the ballistic parameters resulting from every acceptance firing are respectively averaged with the same parameters from the preceding and succeeding firing. Firings are made in equal numbers of units conditioned to the three required temperatures, hot, cold, and normal; and all ballistic parameters are adjusted to represent the firing of a unit conditioned at normal temperature. Acceptance or rejection is on the following basis:

1. From the production of the first sublot under this plan, three production units are selected at random and fired, one at each of the three temperatures. Adjusted values of all ballistic parameters must individually meet the limits specified and fall within upper and/or lower reject limits.

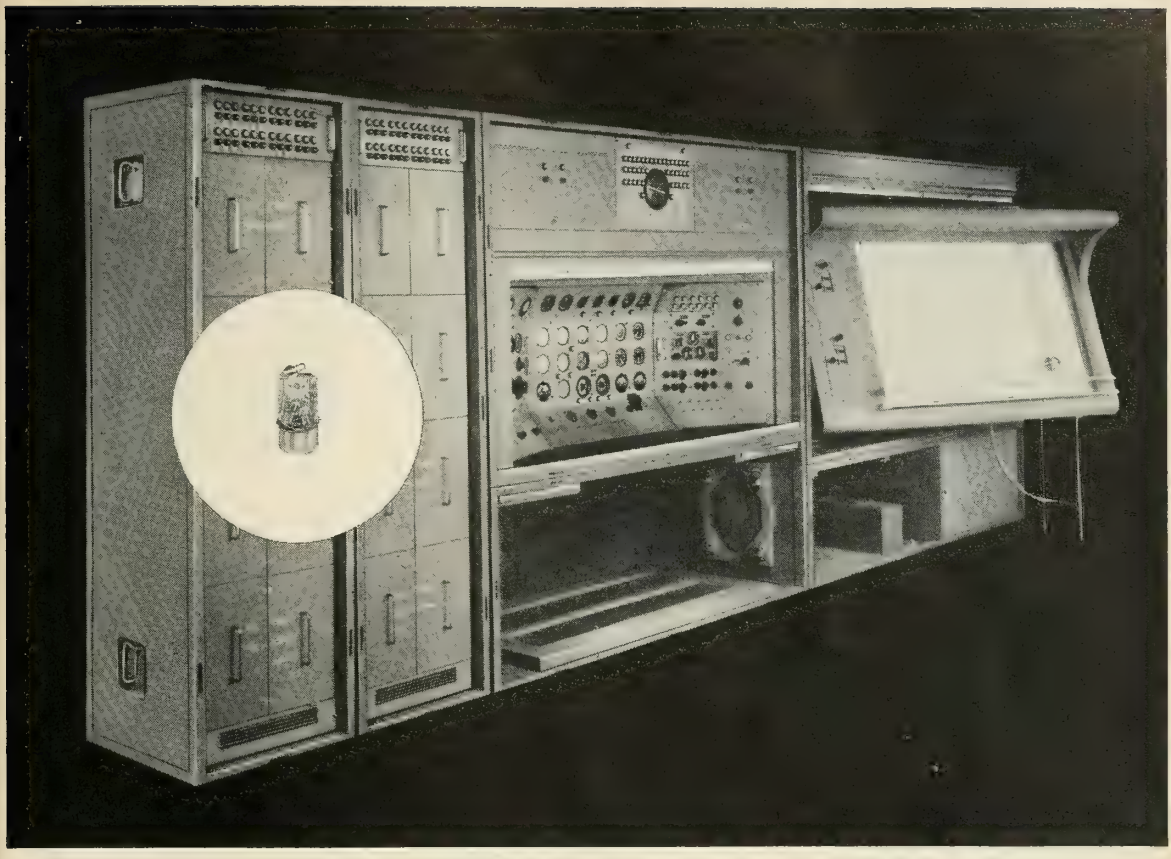
2. If Paragraph 1 is met, then one per cent of units produced (and not less than one unit), randomly selected from each sublot, are fired, and a moving average maintained of the results of the last three firings. This moving average must remain within limits for averages, and individual parameter values for the last firing must also remain within acceptable limits.

3. If an individual firing of a sample unit yields any ballistic result which fails to meet limits for individual units, then the sublot represented by that unit is rejected. If the moving average for any parameter fails to meet limits for averages, then the three sublots represented by that average are rejected.

4. Alteration of firing temperatures is done in such a manner that units from any one eight-hour shift will not always be fired at the same temperature.

It has been apparent from the results to date that the fractional continuous variables acceptance sampling plan for ballistic parameters of M15 JATO has been much more feasible than lot-by-lot variables sampling. It has been more economical, since it has resulted in much less than half the number of firings necessary to yield the same assurance using a small lot variables sampling plan and has made unnecessary any provision for additional storage capacity for large lots. It has been more rapid in furnishing usable information and more sensitive to defective material than would lot-by-lot acceptance of small lots of units.

One area of caution regarding the use of this plan concerns the greater degree of sensitivity afforded by the moving average for the various parameters. It is quite possible, due to a slight shift in the mean for any certain parameter, for one or more sublots occasionally to be rejected when in actuality all units in the sublot are within individual limits. This problem cannot be considered a defect in the sampling plan, since the sensitivity of the moving average is desirable. However, it does necessitate the recognition by the procuring agency, as well as the manufacturer, that sublots which are rejected by a moving average found slightly outside limits, should be evaluated through additional firings.★



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Reinforced Plastics for Rocket Applications

Reinforced plastics are being used not only in secondary, but in primary rocket structures as well where successful performance is essential. For short, one-shot operations their temperature tolerance often exceeds that of their metallic counterparts. The unique service conditions for rocket-motor hardware often necessitate a search for unconventional materials or the adaptation of existing materials to an unconventional use. Adiabatic flame temperatures of several thousand degrees fahrenheit for relatively long exposure periods, are routine requirements for rocket-motor and missile manufacturers. High gas velocities at these elevated temperatures often are encountered. The thermal properties of reinforced plastics make these materials desirable when compared to metallic structures. Furthermore, combinations of reinforced plastics and metals can effect significant weight reductions.



Here are just a few of the rockets and missiles shapes capable of being fabricated of reinforced plastics, which promise increased flexibility and economy.

Founded in 1942 by Dr. Theodore von Karman, the Aerojet-General Corp. has expanded its activities to include almost all possible applications of rocket power. Recognizing the potential of reinforced plastics in producing lighter weight, more efficient, or otherwise more suitable structures, Aerojet management encourages continuing activities in development of novel designs involving reinforced plastics. Some of these developments are finding their way into non-rocket applications.

George Epstein, J. W. Ederhardt, Jack Goldberg and H. A. King of Aerojet recently presented a paper, "Reinforced Plastics for Rocket Applications," at the Annual Conference of the Society of the Plastics Industry. This article extracts that paper.

Glass reinforcements are used primarily in conjunction with polyester, epoxy, elevated-temperature-resistant phenolic, and silicone resins. Asbestos reinforcements, refractory powders, and other filler materials are also used. Fabrication techniques include layup, matched-die molding, filament winding, casting and adhesive bonding.

The advantages of reinforced plastics in rockets include: high strength-to-weight ratio; desirable thermal insulating properties; ease of fabrication into complex configurations; use of non-critical materials; wide versatility in selection and formulation of resin-curative-filler (reinforcement) systems; low-cost tooling and fabrication techniques; resistance to various environments, e.g., moisture, sea water, weather, fungi, solvents and fuels, acids and alkalies; non-magnetic properties; excellent electrical properties.

Reinforced plastic structures are employed in rocket applications for various temperature exposures. Polyester and epoxy resins usually are used for service at low temperatures (between −65 and + 200°F). For service at intermediate temperature ranges (200 to 500°F), and at high tempera-

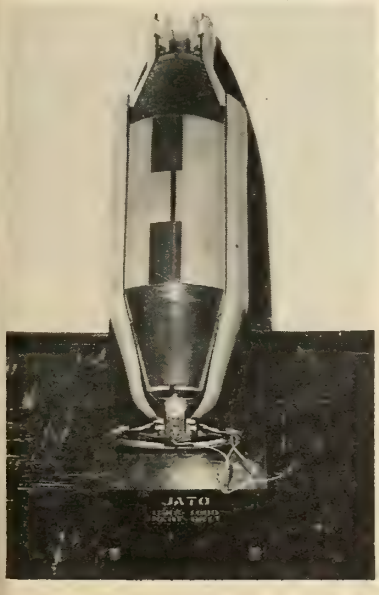


tures (500 to 1000°F), heat-resistant epoxy, phenolic, triallylcyanurate-modified polyester, and silicone resins are employed, with silicones usually limited to long-duration or repeated exposures. Reinforced plastics also are used when exposure is required for extremely short durations (several seconds or less) to temperatures of over many thousands of degrees.

Aerojet developed the modified-epoxy-resin formulation employed in glass-reinforced-plastic liners for insulating nozzle adapters in rocket motors during operation of a safety device. Service conditions require exposure to temperatures of over 3000°F for several seconds in a high-velocity gas stream. Fabrication costs of this structure are approximately one-half those for a "conventional" heat-resistant phenolic resin.

A JATO unit contains several reinforced-plastic components. The Tee baffle is subjected to gas temperatures of approximately 3800°F and gas velocities up to several hundred feet per second for a duration of approximately 15 seconds. In addition to providing a thermal barrier, this phenolic-resin, glass-fabric-reinforced structure suppresses instability which might occur during combustion of the solid propellant. A reinforced-plastic cone is also used in this rocket, serving as a safety-diaphragm deflector. An external exhaust deflector of glass-reinforced-phenolic-plastic employed with the JATO in order to confine the high-velocity exhaust jet and deflect it from adjacent aircraft surfaces. In a normal firing, the high-velocity exhaust gases

Cross-section of a rocket motor showing the increasingly important role being played by reinforced plastics.





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Numerous agencies engaged in the manufacture and evaluation of missiles have turned to the Century Model 409D Recording Oscillograph as a reliable means of collecting missile performance and control data.

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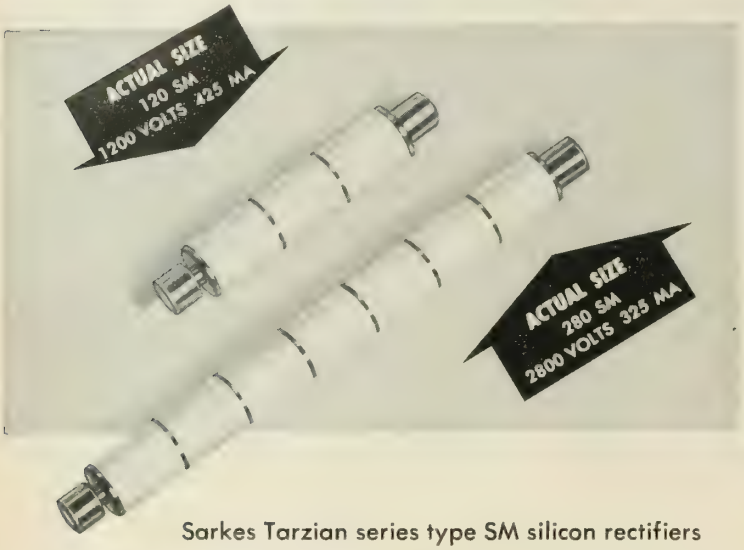
This 13 lb. instrument is compact enough to be installed in most missiles and all electrical connections including remote control are accomplished through a single multi-pin AN connector.

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80SM	800	560	450	225	1.12	560	4.5	2.25	27.0	13.5	1N1108
120SM	1200	840	425	212	1.06	.530	4.25	2.12	25.5	12.7	1N1109
160SM	1600	1120	.40	200	1 00	500	4 00	2.00	24.0	12.0	1N1110
200SM	2000	1400	375	187	940	470	3.75	1.87	22.5	11.2	1N1111
240SM	2400	1680	.35	175	875	437	3 50	1.75	21 0	10.5	1N1112
280SM	2800	1960	325	162	812	405	3.25	1.62	19 5	9.7	1N1113

DIMENSIONS

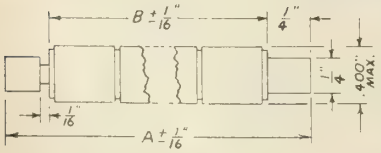


Figure 1

Figure 1 A	Figure 1 B	JETEC NO.
1-15/32"	31/32"	1N1108
1-15/16"	1-7/16"	1N1109
2-13/32"	1-29/32"	1N1110
2-7/8"	2-3/8"	1N1111
3-11/32"	2-27/32"	1N1112
3-13/16"	3-5/16"	1N1113

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are confined by the plastic part, which is capable of being used for several normal firings.

Honeycomb plastic sandwich was fabricated for a stabilizing-control-surface part on an advanced *Aerobee* sounding rocket. Elevated-temperature-resistant, reinforced-plastic skins, core, and attachment edges are joined with a heat-resistant structural adhesive. The leading edge of this sandwich part has a herring-bone pattern designed to provide optimum resistance to erosion during high-speed flight.

A number of the guided-missile warheads have made extensive use of glass-reinforced-plastic structures to take advantage of minimum parasitic weight and increased strength-to-weight ratio, and to provide versatility in design. Warheads using reinforced-plastic structures and adhesive-bonded-metal components have successfully withstood the most severe military environmental tests and, in many cases, warheads subjected to these tests have been completely usable when their metal counterparts would have been rendered completely useless.

Filament winding provides a means for obtaining the maximum strength-to-weight ratio in reinforced plastics by locating each strengthening filament of glass at its optimum position. Thus, if the structure is to be stressed in one direction only, all (or nearly all) of the filaments can be applied in such a direction as to counteract this force. Pressure spheres made this way have been produced in diameters from 1½ to 21 inches and varying in design burst pressure from less than 100 to over 10,000 psi.

Such spheres are used as pressure tanks in aircraft hydraulic systems, in missiles and rockets to pressurize liquid propellants, and high-pressure containers in general. Two 12 inch filament-wound spheres mounted in an *Aerobee* sounding rocket. This type of installation was employed in the widely-publicized "Firefly" project of the Air Force. Nitric oxide gas was contained at a pressure of 3000 psi and released at an altitude of 56 miles during upper atmosphere research investigations.

Plastics engineers in the rocket industry are pioneering in the areas of high temperature and high-pressure applications of reinforced plastics. Many of the accomplishments to date have been achieved primarily as a result of close cooperation between material suppliers, engineers, and fabricators. It is expected that continuing cooperation in the development of new materials and techniques will promote rapid expansion in the utilization of reinforced plastics in the rocket industry.

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	Volts	Amps.	Volts	Phase	VA Rating			
12128	27.5	1	26	1	6	35,000	2.2	AN3496
12126	27.5	2	26	3	10	35,000	2.3	E1615
32B21	27.5	3	115	1	20	50,000	5	—
MG-93	27.5	12	115/200	1 3	100 100	65,000	10	E5134
MG-54	27.5	22	115/200	1 3	250 250	50,000	17	E5109
12142	27.5	22	115	1 3	250 250	35,000	13	E1617
12143-1	27.5	22	115	3	250	35,000	13	—
12143-2	27.5	22	115	1	250	35,000	13	—
*32B15	27.5	22	115	3	300	50,000	14	—
32E01	27.5	35	115	3	500	50,000	26	AN-3533-1
32E00	27.5	51	115	1 3	500 750	50,000	34	AN-3534-1
MG-65	27.5	52	115/200	1 3	750 750	50,000	35	E52805-2
MG-61	27.5	126	115	1	1750	50,000	54	53C6767
1518	27.5	126	115	1 3	1500 1800	20,000	37	—
32E06	27.5	160	115/200	1 3	2000 2250	50,000	56	E1725
32E03-3	27.5	150	115	1	2500	50,000	58	53B6227
*32E03-8	27.5	160	115	1	2500	50,000	65	53B6227
*MG-77	27.5	150	115/200	3	2500	50,000	65	—
*32B49	27.5	160	115/200	1 3	2500 2500	50,000	65	E54807
MG-81	27.5	160	115/200	1 3	2500 3000	50,000	61	E1725
MG-95	27.5	160	115/200	1 3	2500 3000	50,000	58	E54807
32E09	27.5	160	115	1 3	2500 3000	50,000	60	—
32B27	27.5	285	115/200	1 3	3500 4000	50,000	76	—

*These inverters have magnetic amplifier "static" type voltage and frequency regulators.
NOTE: D.C. Input Voltage shown is nominal value of 27.5 volts, but all units are designed for 26 to 29 volt operation. Input amperes shown are rated at 27.5 volts input.

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Vibration resistances range from 10-55 cycles at 1/16" double amplitude to 55-2,000 cycles at 20 "G"; operational shock resistances to 50 "G" plus, and mechanical shock resistance up to 1,000 "G". Nine standard mounting arrangements, plus a ceramic plug-in socket, are available. The unit displaces only 1.6 cubic inches, excluding terminals.

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engineering briefs

Expanding exotics: Callery Chemicals has broken ground on a $38 million plant that will grind out high energy boron fuels for the Navy. By 1958 the facility will produce a compound called "Hi-Cal" which was developed by Armour Research Foundation. Olin Mathieson is starting construction on a $36 million facility at Model City near Niagara Falls for the production of "Zip" chemical fuels for USAF and a smaller plant at the same site for the Navy. Meanwhile, tank car quantities of boron trichloride will be available by Stauffer Chemical at its Niagara Falls plant. Stauffer is also planning to produce other metal chlorides in a new $1 million expansion.

*

Marriage of propulsion and guidance looks near for Thiokol. The propellant firm recently acquired National Electronics Labs of Washington, D. C. Recently, Aerojet expanded its electronics operations (Avionics Div.) under an $880,000 program. Another propellant firm—Atlantic Research—is also in electronics and is marketing a line of transducers, amplifiers, and even a solid propellant strand burner.

*

Position of normal propyl nitrate is uncertain. After a recent accident, one service is considering abandoning its use. AMF is still said to be doing work on NPN and GE has come out with a pump to handle the nitrate. AMF is said to be going great guns on use of ethylene oxide—mostly APU's for the ICBM program.

*

Studies in the controlled thermal decomposition of cellulose nitrate may lead to clues in the complex combustion mechanism of double base solid propellants. Work at Aberdeen Proving Ground is being carried on with propellant type cellulose nitrate. In ignition and combustion at low pressures, a solid nitrated oxycellulose low polymer is obtained. At somewhat higher pressures a whole line of organic fragments resulted. Some HCN was also found at all pressures and is believed to come from residual solvent.

*

Developments in aircraft nuclear power plants and power reactors may usher in a new age of steam power for conventional aircraft. One firm is replacing the pile with a modern fuel combustor and uses compound vapor systems to run a closed cycle turbine. Now being investigated are water, ammonia, and isopropyl biphenyl.

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Systems Design Engineer: Before his recent promotion, this man planned electronic digital computers through development and evaluation of logical configurations and electronic circuits. He used linear and pulse circuits employing transistors and other semi-conductors; evaluated test data from development models for speed, reliability, data processing capabilities. *Could you handle his responsibilities?*



Transistor Logic and Circuit Designer: Also promoted recently, this man formerly planned, tested and evaluated advanced electronic digital computer circuitry. He guided the building of original circuits through the development model stage. Other assignments in associated fields: advanced component development, specialized projects in ferromagnetics, optics. *Could you handle his responsibilities?*

Challenging jobs are now open!

Organized only 20 months ago, IBM Military Products Division has grown enormously, opening up career opportunities to engineers and scientists in all these fields:

- Circuit Development
- Components
- Cost Estimating
- Digital and Analog Systems
- Electronic Packaging
- Electronics
- Field Engineering
- Heat Transfer
- Human Engineering
- Inertial Guidance
- Installation
- Mathematics
- Mechanical Design
- Optics
- Physics
- Power Supplies
- Programming
- Reliability
- Servo-Mechanisms
- Systems Planning and Analysis
- Technical Publications
- Test Equipment
- Transistors

At the new plant and laboratory in Owego, N. Y., IBM designs and manufactures advanced airborne analog and digital computers for Air Force bombing-navigational equipment. At the new Kingston, N. Y. facilities, IBM builds the world's largest electronic computers for Project SAGE, part of our nation's giant defense net.

The electronic computer field offers one of the best ground-floor career opportunities today. Economic experts rank the electronic computer in importance with automation and nucleonics in growth potential. Sales at IBM, the recognized leader in the field, have doubled, on the average, every 5 years since 1930. Engineering laboratory personnel quintupled in the past five years. Future expansion plans offer even better opportunities.

As a member of IBM Military Products, you enjoy the stability and security of the IBM Corporation, plus the opportunity to progress in any other IBM division. Promotions open up frequently from continuous growth. The "small group" approach assures recognition of individual merit. Salaries are excellent and company-paid benefits set standards for industry.

Where would you like to work for IBM?

This map points out key IBM plants and laboratories, including the Military Products facilities at Owego and Kingston, N. Y. Limited openings are available at many flight test bases and SAGE computer sites across the nation.



SEND COUPON TODAY!

R. A. Whitehorne, Dept. 6904
Mgr. of Engineering Recruitment
IBM Corp., 590 Madison Ave.
New York 22, N.Y.

Please send me additional information.

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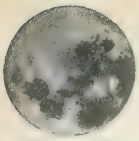
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IBM MILITARY PRODUCTS

DATA PROCESSING
ELECTRIC TYPEWRITERS
TIME EQUIPMENT
MILITARY PRODUCTS



Missile Miscellany

From a combat soldier who should know, this capsule appraisal of a missile family: Redstone—a monstrosity, payload too big for range; Corporal—a misfit, range, complexity and logistics too much for tactical requirement; Honest John—the soldier's pal, highly mobile, designed for the job; Lacrosse—a precision pillbox getter with five-yard maximum error per mile range, truck transportation with go-nogo box the size of TV creepy-peepy; Little John—designed to cut out need for AF close support; Dart—Army nearly did to a good French design what Martin and AF did to the Canberra.

And while this page is apparently picking on other people's pet projects, developing preference for Nike over Talos may be due to the fact that Talos electronic gear requires over 250 "wall cabinets." Nike takes much less.

A telephoned warning this page respects, quoted by a Government man of science from University of Chicago bio-chemist Jaques Loeb: "If a man claims there is a gaseous verterbrate floating around the atmosphere, it is clearly his duty to prove it and not the duty of every other scientist to disprove. Otherwise we'd spend our lives disputing the claims of every charlatan and crackpot."

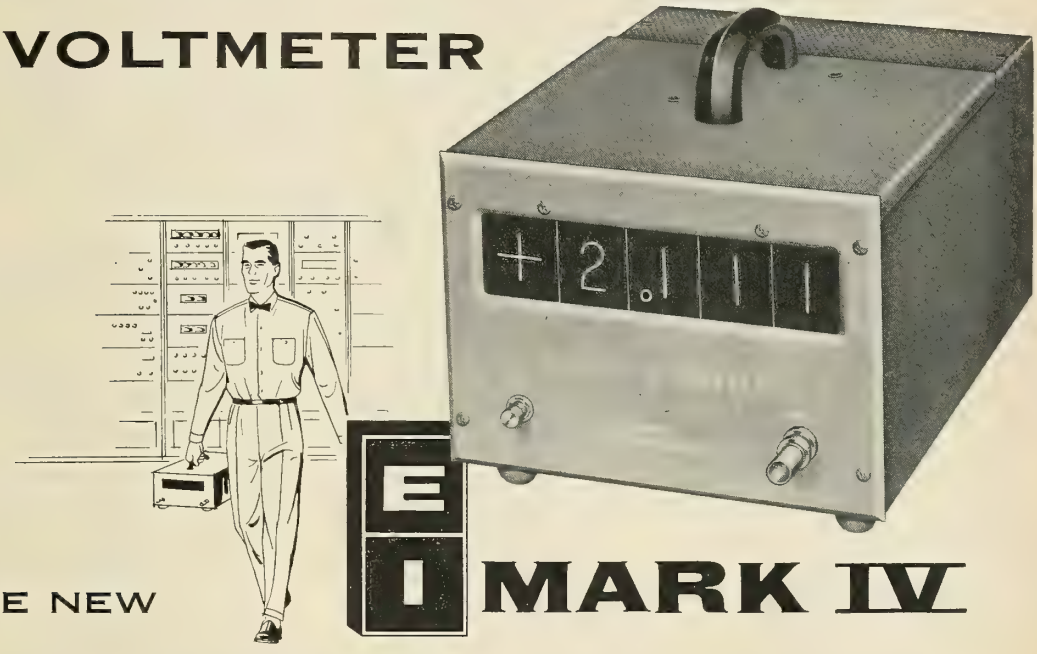
In contrast, this from a physicist turned editor: "Einstein's was an unfettered mind. He ignored the dogmas of ages past and hypothesized solely on the basis of observed phenomena and, thus, was able to provide a wholly new approach to man's universal environment. Now there's danger this product of a free mind will be used by men of science as an excuse for restricting their own thinking."

Basic Army strategy in the AF-Army squabble is aimed at keeping ABMA in the Army and in one piece. Reasoning is that roles and missions decision denying Army the right to use IRBM weapons will sooner or later be reversed, and Army wants to have its hotshot weapons development group intact when that happens.

And a tip to missile peddlers: It's odds on the recent U.S.–U.K. Bermuda deal will give Britain choice of Thor or Jupiter: Nike or Talos. Same for France. These prototype agreements will set pattern for other NATO powers where U.S. will supply hardware but not manpower for manning European missile bases.

Now quick and fast across the spectrum—Unstable subatomic particles accelerated to near-light velocities decay more slowly than they do at rest, which may be first man-made evidence of Relativistic time-lengthening . . . will close observation of Saturn's spinning rings give similar support to Relativity's length-velocity relationship? . . . Wernher von Braun's back to his jig-saw puzzles, dreaming up a super-Jupiter-C, maybe? . . . a future m r contributor tells of a BBIM, Buoyant Ballistic Inertial Missile that doesn't require any propulsion to go hundreds of miles . . . AF has fixed the external configuration of the Thor; anything to be changed will be internal—a Jupiter in Thor's clothing, maybe . . . lest we forget, the same fuel that smoked up grampa's lampshades will power man's first venture into outer space . . . from NACA director Dr. Hugh Dryden out of context at Congressional hearing: "There is no doubt missiles are coming." . . . while a Regulus with extra fuel tanks has made a successful RATO launch, word seeps through that air-to-surface-ship Petrel will be phased out to make way (and money) for higher priority projects . . . brief word of work at Aerojet on underwater pulsejets recalls Dr. Fritz Zwicky's earlier claim that ramjets can run through earth as well . . . a proprietary-minded technical salesman wonders about the system whereby an overall missiles system monitor also designs and manufactures products in competition with contractors whose latest developments he monitors . . . NACA's A. M. Rothrock says turbojets are good to Mach 3; ramjets, from Mach 3 to Mach 6; and rockets, from Mach 6 to Mach 25 . . . and to the right appears a good replica of how results of years of effort and many dollars expended sometimes turn out . . .

NOW! A PORTABLE, PRECISION DIGITAL VOLTMETER



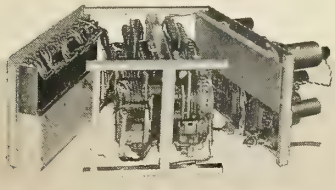
THE NEW E-I MARK IV

This newest E-I instrument provides the perfect general-purpose voltmeter for both laboratory and field use.

Operation is completely foolproof; no manual adjustments or calibrations are required. Measurements are made automatically and results presented digitally with easy-to-read, 1"-high numerals, arranged in line.

A new electronic amplifier design (reducing the number of tubes to only eight!) and advanced miniaturization techniques have reduced the overall size of the new Mark IV to only 7½" x 9" x 11", and cut the weight to 28 pounds.

Ask your local E-I representative to give you the complete story, or write direct for our new brochure.



UNUSUALLY EASY TO SERVICE

The one-piece hood houses three distinct sub-assemblies: amplifier, power and reference supplies; balance circuit; and read-out. Each sub-assembly is pivoted for excellent accessibility to all parts.

SPECIFICATIONS

Display: four digits, polarity, decimal point.
Range: 0.001-999.9 volts dc.
Ranging: automatic.
Polarity: automatic.
Accuracy: 0.05%, ±1 digit.
Input impedance: 11 megohms.
Average balance time: 1 second.
Calibration: self-calibrated.
Stability: 0.003%/C°.

The complete line of digital instruments

ELECTRO INSTRUMENTS INC.

3794 Rosecrans Street, San Diego, California

Circle No. 49 on Subscriber Service Card.

What does it do between

HERE and . . .



THERE?

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The proof of any guided missile is its performance. Not only is it necessary to provide accurate trajectory data in order to determine its effectiveness, but this must be made immediately available.

To meet both requirements is the purpose of the AN/FPS-16 instrumentation radar. This is the first radar developed specifically for Range Instrumentation. It has demonstrated its ability to track with accuracy in darkness, through clouds—under any atmospheric conditions—over extended ranges, and to yield data that can be reduced almost instantaneously to final form. This unit can also be assigned to plot performance of missile, satellite, drone and other free space moving targets.

In the past, this data has depended upon optical devices, triangulation systems with long base lines and precision limitations, modified radar equipment and data reduction methods often requiring months for computation. The immediate availability of data evaluation provided by the AN/FPS-16, now being built by RCA under cognizance of the Navy Bureau of Aeronautics for all services, is a great forward step in Range Instrumentation.

Defense Electronic Products

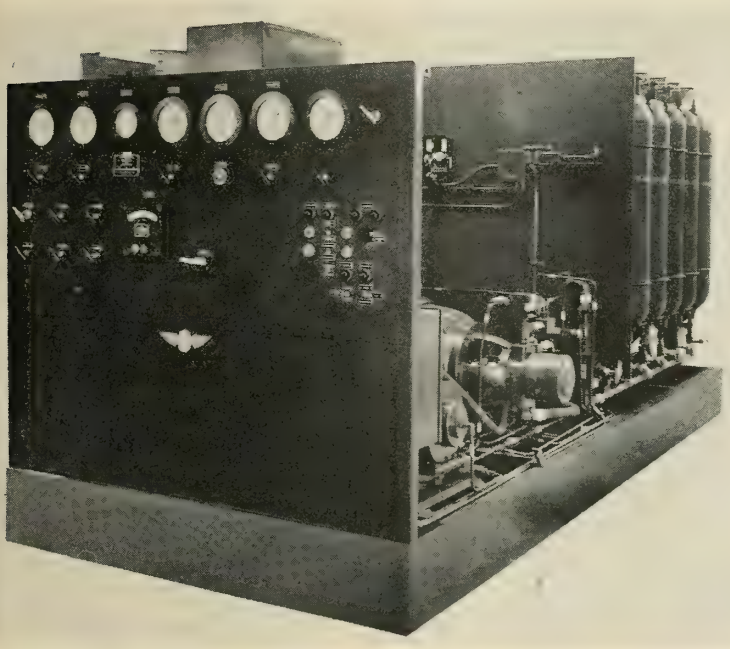
RADIO CORPORATION of AMERICA

Camden, N.J.

Tmk(s) ®

NEW MISSILE PRODUCTS

HIGH PRESSURE GAS BOOSTER



A new high pressure gas booster developed by Greer Hydraulics, Inc. for testing rocket engines and components is capable of boosting pressures up to 10,000 psi at nominal flows up to 10,000 scfh.

The Greer unit, designed to deliver uncontaminated boosted gas, is proposed for a variety of missile and rocket uses. According to Greer, portable and stationary large-capacity units can be remotely controlled for charging a missile receiver before launching. A smaller stand is adapted to checking missile components, gases and pressure switches.

For dynamic check of missile components, large-capacity stands will supply large continuous flows and can be supplied with gas-recovery features to conserve helium. Other portable, low-capacity models can be used to supply uncontaminated gas pressurization to missiles or components at launching sites.

Circle No. 210 on Subscriber Service Card.

MISSILE FAN

A new landmark in miniaturization is the claim of Rotron Manufacturing Co. for its 2 in. diameter, 1½ in. long Aximax fan to cool missile electronic equipment.

Of vaneaxial design, the Aximax II features inside-out motor construction wherein the electrical rotor and air-moving impeller are integrally cast in one piece. Unit weighs only four ounces and is rated to move 62 cubic feet per minute of air at free delivery and 43 cfm at 2 in. static pressure.

New fan operates at 20,000 rpm, is wound for 400 cycle a-c, either 200 volt, three phase or 115 volt, single phase.

Circle No. 212 on Subscriber Service Card

VIBRATION TESTER

New "economy" vibration test machine introduced by The Ahrendt Instrument Co., subsidiary of Litton Industries, weighs only 30 lbs. and will handle testing of small items up to five pounds.

The Model 14-28 test machine conforms to frequency and amplitude requirements of MIL Standard No. 202 and is said to be extremely valuable for interim testing during development as well as for final test or production line quality checks.

Variable-speed drive and 1/15 hp split-phase induction motor of the Model 14-28 are housed in a cast aluminum base. Linear sinusoidal motion is carried to a flex-mounted table via a connecting rod driven by a ball bearing mounted eccentric cam.

Frequency adjustment is infinitely variable between 10 and 55 cycles per second while the machine is running and frequencies down to 2 cps are available at extra cost. Amplitude setting from zero to 0.040 in. (double amplitude maximum is 0.080 in.) is provided by means of an eccentric adjustment. Literature available.

Circle No. 201 on Subscriber Service Card.

CANNON CONNECTORS

Two new connectors—a high speed, high altitude design and an AN quick-disconnect type—have been unveiled by Cannon Electric Co.

The former, a rack/panel pressurized connector, is intended for high-altitude and high vibration applications and features use of a special rubber seal about its insert faces upon mating.

The quick-disconnect unit is basically an accessory made up of an adapter and coupler designed for standard AN connectors. Adapter is designed to screw over coupling threads of AN receptacle and contains an external locking groove which receives the formed ends of the coupler latch when fully engaged.

Cannon coupler is a special spring latching assembly designed to replace coupling nuts on standard AN3106 and AN3108B plugs.

Circle No. 215 on Subscriber Service Card.

FRACTIONAL HP MOTORS

New 400-cycle, 200 volt, three-phase, two-speed, constant torque motors introduced by Western Gear Corp. operate at speeds of 7,200 and 1,200 rpm and are available at ¼ hp and 1/24 hp respectively.

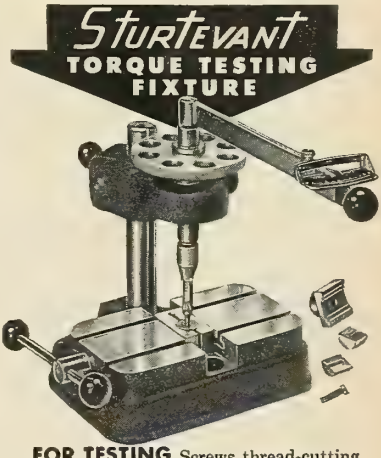
Western Gear's Model 1H58ML1 is "pancake" shaped, weighs 6.5 lbs. and measures 2½ in. deep by 3¾ in. in diameter. Output speeds are said to be plus or minus 5% with controlled acceleration and deceleration.

Circle No. 213 on Subscriber Service Card.

MINIATURE VIBRATOR

P. R. Mallory & Co., Inc. is marketing a new miniaturized vibrator that weighs only 1.5 oz. and measures 1¼ in. high by ¾ in. diameter. The Mallory 1900 series was developed for use in missile power supplies, primarily for guidance system applications.

New vibrator is rated for shock loads of 9,000 g's and above and is said to have performed satisfactorily after a shock exceeding 17,000 g's. It was not affected by spin test accelerations from



FOR TESTING Screws, thread-cutting and thread-forming screws—all types of threaded fasteners; threaded parts and threaded connections.

FOR MANUFACTURERS
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in assembly.

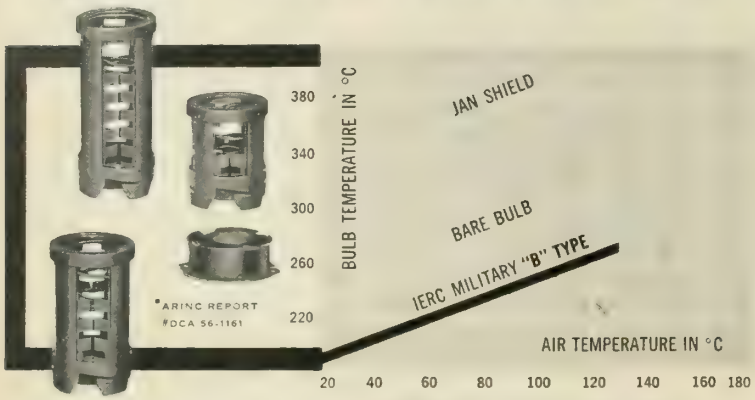
Capacities: (0-200 in. lbs.) or (0-150 ft. lbs.)

Write for Bulletin TTF

P. A. Sturtevant Co.
Addison (Quality) Illinois

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NOW—increase electron tube life *12 TIMES!

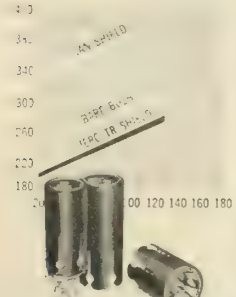


COMPARISON OF COOLING EFFECTIVENESS

Exclusive IERC Tube Cooling Effectiveness Provides Greatly Extended Tube Life And Reliability!

Though electronic engineers know that even the *slightest* tube temperature reduction improves tube life, the greatest success enjoyed in obtaining *extended* tube life has been when IERC Heat-dissipating Tube Shields have been specified and used. Results show that extensive gains in tube life and reliability are easily achieved—that tube operating temperatures are reduced as much as 150°C—that IERC's Military Type "B" shield is the *only effective answer* to obtain these benefits in *your* new equipment. Positive shock and vibration protection plus electrostatic shielding is provided. Graphs show temperature reductions when IERC "B" and "TR" shields are used with 6005 tube operating at full plate dissipation.

PATENTED OR PATS PEND. CROSS-LICENSED WITH NORTH AMERICAN AVIATION, INC.



Retrofit For Maximum Tube Life

No modification is required with IERC "TR" Type Heat-dissipating tube shields! TR's fit easily to existing JAN sockets—greatly extend tube life through excellent cooling and retention against shock and vibration.

Complete IERC literature and Technical Bulletins sent on request. WRITE TODAY!

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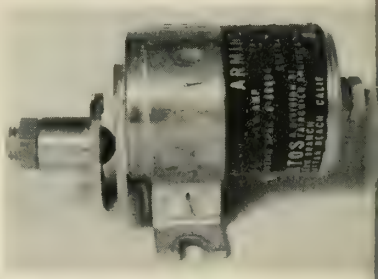
Circle No. 32 on Subscriber Service Card.

standstill to 13,000 rpm, according to Mallory.

Designed for intermittent service, new vibrator is a 400 cycle, full-wave interrupter type that will deliver up to 20 watts for short periods.

Circle No. 217 on Subscriber Service Card.

ARMING SOLENOID



An 11-ounce arming solenoid introduced by Stratos Division, Western Branch, is designed to arm missiles in high performance fighters, but can be adapted to other high-altitude applications according to its producer.

Unit operates unpressurized and, although qualified to 80,000 ft., has been tested successfully to 115,000 ft. Solenoid operates down to 18 volts and normal power drain is .7 amperes.

Circle No. 205 on Subscriber Service Card

MINIATURE PLUGS

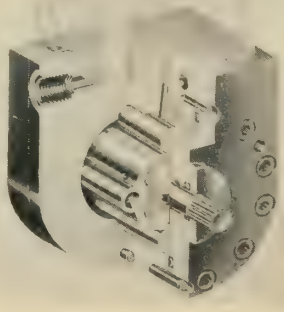
Microdot, Inc. has unveiled two new miniature coaxial plugs, series 32-66 and 32-68, designed for use with Teflon RG-195U miniature coaxial cable having a maximum outside diameter of 0.155 in.

New plugs feature assembly without special tools and adaptability to use with existing Microdot S-93 receptacles. Series 32-66 plug has a guarded center pin.

Circle No. 219 on Subscriber Service Card.

ROTARY HYDRAULIC ACTUATOR

Aviation Division of Kelsey-Hayes Co. has unveiled a new rotary hydraulic actuator intended for use in precision control servo systems using fluid supply pressures in the 3,000 to 4,500 psi range.



New actuator ranges in size from 100 lb. in. to 6,000 lb. in. stall torque based on a 3,000-psi supply pressure rating. Static breakaway friction is said to be less than 6 lb. in.; internal leakage

50 x 10-6 in. 5/lb. sec. and total angular travel 125°. Actuator has a static breakaway friction of less than 1% maximum stall torque, according to K-H.

Circle No. 211 on Subscriber Service Card.

COOLANT PUMP

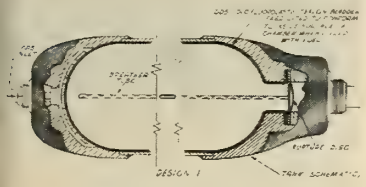
New lightweight coolant pump introduced by Applied Dynamics Corp. weighs about three pounds and is designed for such applications as coolant circulation in missile guidance systems.

The ADC pump, in a typical 3-pound model, measures 8 in. long and 3 in. diameter and operates from 400 cycle power source. Design feature is leakproof construction utilizing a "canned" motor that requires no seals or stuffing boxes. Available designs are of centrifugal or positive displacement types.

Circle No. 214 on Subscriber Service Card.

EXPULSION BLADDERS

Joclin Manufacturing Co. has announced development of fluorolastic Teflon seamless fuel bladders for handling fuels and oxidizers in missile propellant systems. Units are of the expulsion type in which gas is introduced at one end of cell to propel fuel from the other.



According to Joclin officials, the new container and fuel bladder combination is the result of two years of research to develop equipment that would cope with the 1,000-degree spread between —450° and 550° temperatures experienced in high altitude missile, ramjet, rocket engines.

Circle No. 206 on Subscriber Service Card

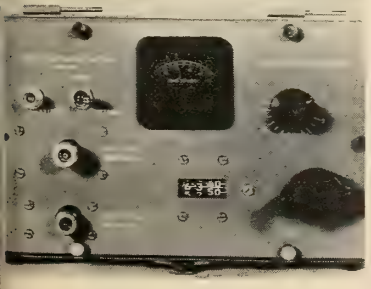
TEMPERATURE PROBE

Total temperature probe developed by Aero Research Instrument Co. for missile use is available with a choice of resistance thermistor of thermocouple sensing elements. Resistance elements are designed for operating ranges up to 1,000°F; thermocouple elements to 2,800°F. Probes are said to be completely insensitive to 20-degree angle of attack or yaw.

Circle No. 208 on Subscriber Service Card

FREQUENCY METER

An improved Model 802 Narda frequency meter has a range of 2,350 to 10,500 mc. The instrument has also been





for precision short-run machine operations on your small, intricate prototypes involving sub-assemblies and electromechanical components. Our *completely equipped* plants are presently producing for the leading Military, Electronic and Aviation firms throughout the entire western region. Let us know your requirements—send prints for bids.

20 page brochure on our facilities sent on request—write TODAY!

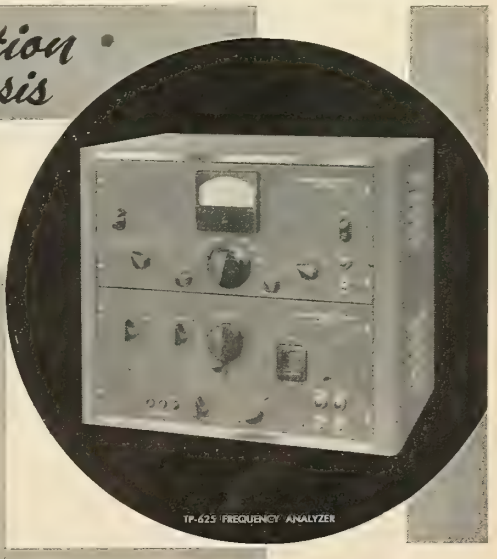
GRIMLEY ENGINEERING CORP.

177 W. Magnolia Boulevard, Burbank, California

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FOR *Vibration analysis*

THE TP-625 FREQUENCY ANALYZER



FEATURES

- LINEAR FREQUENCY CALIBRATION — Manual or Automatic Sweep
- EXCELLENT STABILITY — Temperature Controlled bridge-stabilized oscillator
- CONSTANT FREQUENCY BANDWIDTH — As narrow as 2 cps; as broad as 200 cps
- DYNAMIC RANGE — As great as 66 db (depending upon filter employed)
- SPECTRUM — 2 cps to 25,000 cps
- MULTICHANNEL ANALYSIS — Simultaneous analysis of numerous channels

The TP-625 Frequency Analyzer will determine the recorded frequency-amplitude spectrum of a random wave within the frequency range of 2 cps to 25,000 cps. In addition to analyzing random waves, the instrument will also determine the frequency and amplitude of the individual components in a periodic wave within this frequency range.

Wave components resulting from vibration, pressure, strain, light, etc., can be measured in decibels, in percent of total signal or both. Results are indicated on a calibrated attenuator and on a meter. For permanent, detailed analysis, high and low impedance output are provided to drive a recorder. When equipped with its accessory servo system, the TP-625 will follow RPM, or multiples of RPM, in engines throughout an operating range.

For specifications and further information, write for bulletin 625-1-956.

Technical Products Co.
INSTRUMENT DIVISION
6670 Lexington Ave. Los Angeles 38, Calif.

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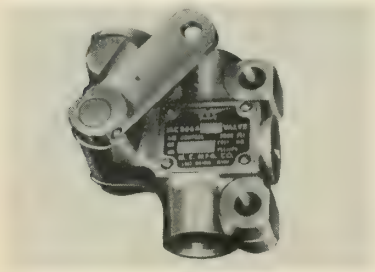
redesigned to give better accuracy and legibility. Principal change is the elimination of two micrometers and substitution of a Veeder-Root digital counter system for frequency readings.

Frequency in mc is obtained without calculations or written interpolation to a rated accuracy of 0.2%. Two tuned cavities are used. They are tuned by a precision lead screw. Both tuning shafts are driven by a single knob. Counter readings are referred to a universal nomograph-type calibration chart. The Narda Corp.

Circle No. 240 on Subscriber Service Card.

CONTROL VALVE

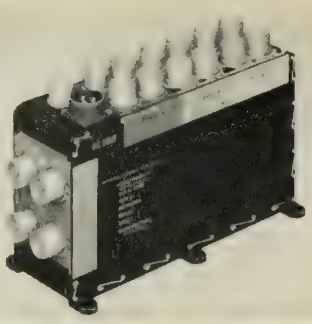
New 3-way air control valve introduced by M. C. Manufacturing Co. is designed for use with air or nitrogen, weighs only 0.28 lbs. and conforms to Spec. MIL-P-5518A and MIL-P-8564.



Valve is rated for operation at temperatures from —65° to 225°F and pressure of 3,000 psi. Internal leakage is said not to exceed one bubble in two minutes with 500 to 3,000 psi applied at pressure port.

Circle No. 200 on Subscriber Service Card.

ELECTRIC SUBSTATION



Miniature electric substation developed by Cole Electric Co. for the Northrop *Snark* missile is designed to transfer 88 electrical circuits and seven signal circuits from ground test power to airborne supply in 2½ seconds. Weighing only 28 lbs., the Cole system is remotely operated and provides instantaneous synchronization—make before break—to maintain a steady, constant power supply.

Substation draws 6.2 amperes at 28 volts for 2.5 seconds maximum. Current used totals 434 watt-seconds, instead of a continuous load as would be necessitated by a large group of relays, according to the manufacturer.

Circle No. 204 on Subscriber Service Card

TRACKING SYSTEM

New track-while-scan radar system developed by Westinghouse Electric Corp. electronic division automatically reports on 72 targets in three dimensions.

New system, is basically a hybrid digital-analog system in which error sensing is an analog function controlled by a digital computer. Latter computes, controls and displays data on all 72 tracks.

Construction features plug-in packaged unit design using printed circuits. All units are broken down into 200 lb pieces each with its individual transit case.

Circle No. 216 on Subscriber Service Card.

MISSILE RANGE RADAR

Radio Corp. of America has unveiled an instrumentation radar system company officials say for the first time permit direct calibration and immediate evaluation of missile performance.



The new radar, developed to join Navy Bureau of Aeronautics and Army Signal Corps specifications, is adaptable to plotting performance of satellite, drone

Electrofilm



HEATING ELEMENTS



ENGINEERED TO FIT YOUR DESIGN

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for contour shapes



LIGHT: Weight 1/10 lb. per sq. ft.; only .012" thick

STRONG: Withstands severe thermal shock

THIN: Near zero thermal inertia. Reduces power requirements due to maximum heat transfer properties

RESISTANT: Resists electrolytes, water, oils, abrasion and weather

WIDE RANGE: Operates any voltage; 6 volts D.C. to 220 volts A.C.



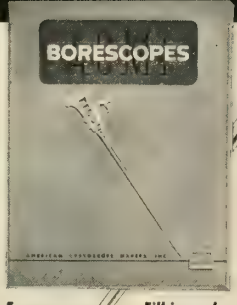
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INSPECTION PROBLEMS?

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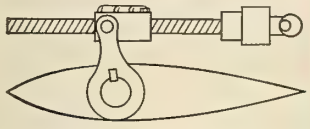
TOO "HOT" TO HANDLE

with ordinary actuators?

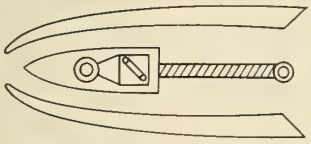
Saginaw b/b Screws and b/b Splines are dependably solving critical guidance and control problems for missile and rocket engineers . . .



TYPICAL APPLICATIONS

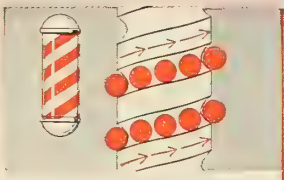


Control surface actuators

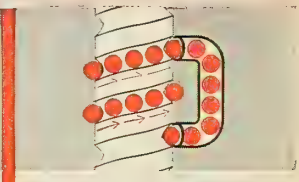


Nose cone positioners

Evelon positioners • Afterburner controls • Speed brake actuators • Rocket engine displacement actuators • Clamping mechanisms for missile boosters • Fuel controls (3-dimensional cams) • Black box tuning devices—telemetering and guidance systems • Antenna coupler tuning mechanisms



Nut *glides* on steel balls. Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.



At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

1 VITAL POWER SAVINGS. With guaranteed efficiency of 90%, Saginaw b/b Screws are up to 5 times as efficient as Acme screws, require only ⅙ as much torque. This permits much smaller motors with far less drain on the electrical system. Circuitry is greatly simplified.

2 SPACE/WEIGHT REDUCTION. Saginaw b/b Screws permit use of smaller motors and gear boxes; eliminate pumps, accumulators and piping required by hydraulics. In addition, Saginaw b/b Screws themselves are smaller and lighter. Units have been engineered from 1½ in. to 39½ ft. in length.

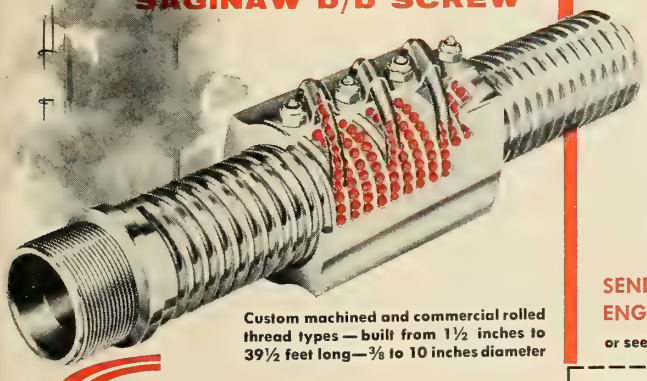
3 PRECISE POSITIONING. Machine-ground Saginaw b/b Screws offer a great advantage over hydraulics or pneumatics because a component can be positioned at a predetermined point with precision. Tolerances on position are held within .0006 in./ft. of travel.

4 TEMPERATURE TOLERANCE. Normal operating range is from −75° to +275° F., but assemblies have been designed in selected materials which function efficiently as high as +900° F. These units are practical where hydraulic fluids have lost efficiency or reached their flash point.

5 LUBRICATION LATITUDE. Even if lubrication fails or cannot originally be provided because of extreme temperatures or other problems, Saginaw b/b Screws will still operate with remarkable efficiency. Saginaw units have been designed, built and qualified for operation without any lubrication.

6 FAIL-SAFE PERFORMANCE. Far less vulnerable than hydraulics. In addition, Saginaw offers three significant advantages over other makes: (1) Gothic arch grooves eliminate dirt sensitivity, increase ball life; (2) yoke deflectors and (3) multiple circuits provide added assurance against operating failure.

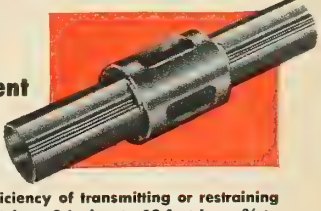
SAGINAW b/b SCREW



Custom machined and commercial rolled thread types — built from 1½ inches to 39½ feet long—⅜ to 10 inches diameter

SAGINAW b/b SPLINE

Averages 40 times lower friction coefficient than sliding splines



Radically increases efficiency of transmitting or restraining high torque loads; built from 3 inches to 10 feet long, ⅜ to 6 inches diameter

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SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS • SAGINAW, MICHIGAN
WORLD'S LARGEST PRODUCER OF BALL BEARING SCREWS AND SPLINES

Saginaw Steering Gear Division
General Motors Corporation
b/b Screw and Spline Operation
Dept. 8S, Saginaw, Michigan

Please send new engineering data book on Saginaw b/b Screws and Splines to:

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A lightweight skin section 5 feet by 3 feet in compound contours. One side an airfoil, the other side a heat collection grid of maximum conductivity through the skin. A tolerance of .010" on mating surfaces.

This casting was produced by a unique foundry technique developed by the aluminum foundry of Morris Bean & Co. A rush schedule was met on prototypes, and the casting is now delivered in production quantities.

If you seek new approaches on difficult-to-form access doors, fins, airfoil sections, leading edges, or other problem shapes, you should become acquainted with—

Morris Bean & Company
Yellow Springs 5, Ohio

a cast aircraft skin?



BEAN

Circle No. 45 on Subscriber Service Card.

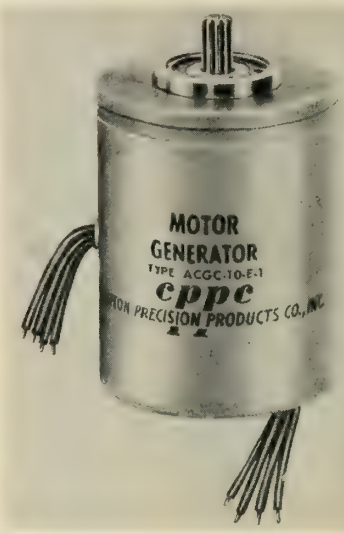
or other free-space moving targets.

Designated AN/FPS-16, the RCA equipment is an evolution of earlier radars it developed for the Johns Hopkins *Bumblebee* project and Army application of Navy's *Terrier* missile system.

Circle No. 209 on Subscriber Service Card

MOTOR GENERATOR

Production of a new size 10 ac motor generator for error rate damping in missile servo systems has been announced by Clifton Precision Products.



Weighing 72 grams, the Clifton unit requires an input power of 0.2 watts and has an output of 0.16 volts per 1000 rpm. No load speed is 7,000 rpm.

Circle No. 218 on Subscriber Service Card.

ROTARY ACTUATOR

A rotary actuator marketed by Electrical Engineering and Manufacturing Corp. has a travel of 45 degrees at .625 rpm. Operating on a 320 to 480 cycle ac frequency range (compared to MIL Spec. 380 to 420 cycles), the EEMCO D-822 actuator is said to eliminate the need for a constant speed drive in aircraft or missile power generation systems. Actuator operates under 26,000 in. lb. normal load with a maximum of 52,000 in. lbs.

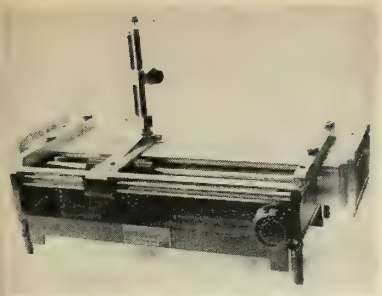


Circle No. 202 on Subscriber Service Card.

SLOTTED LINE KIT

A carriage and slotted line sections are available for taking standing wave measurements in several of the larger waveguide sizes. Slotted sections for 1.7 to 4.9 kmc are available in five sizes. The carriage accommodates four interchangeable slotted sections in different waveguide sizes and slow carriage travel is permitted through vernier positioning of the probe.

The unit can be adapted for remote operation by using a motor drive and limit



switches. The carriage is designed to use most standard probes without alteration. The Diamond Antenna & Microwave Corp.

Circle No. 220 on Subscriber Service Card

LOW TEMPERATURE COUPLINGS

New line of quick couplings marketed by Hofman Laboratories for use in low temperature apparatus require only ¼ turn to open or close. Design employs a mechanical cam action to provide a metal-to-metal medium-pressure contact in place of gaskets for positive sealing.

Produced from high quality bronze, the Hofman couplings are available in 1 in. to 3 in. diameters at ½ in. increments, plus a larger 4 in. diameter model. Hofman also provides armored transfer hoses with couplings installed.

Circe No. 239 on Subscriber Service Card.

SHOCK MOUNTINGS

New series of light-weight shock mounting devices introduced by Shur-Lok Corp. are designed for use in electronics, radar and missile applications. New units include six types of electronic clamp assemblies, four of the hinged type. Another Shur-Lok device is a mating electronic equipment hook for vertical and horizontal attachment at a maximum angle of 92 degrees.

Circle No. 207 on Subscriber Service Card

INSTRUMENT TRANSLATOR

A transistorized instrument translator permits substitution of variable reluctance electro-mechanical pickoffs for potentiometers in missile systems without adding much weight and size.



The translator receives power from the system source, whether ac or dc, and when connected to a suitable ac sensing transducer produces an ac or dc signal proportional to the transducer sensed signals. Various models are available to operate motors, recorders, hydraulic valves, servo motors, etc. The unit is

from [illegible] Inc.

. . . another startling new development in automatic electrical system testing!

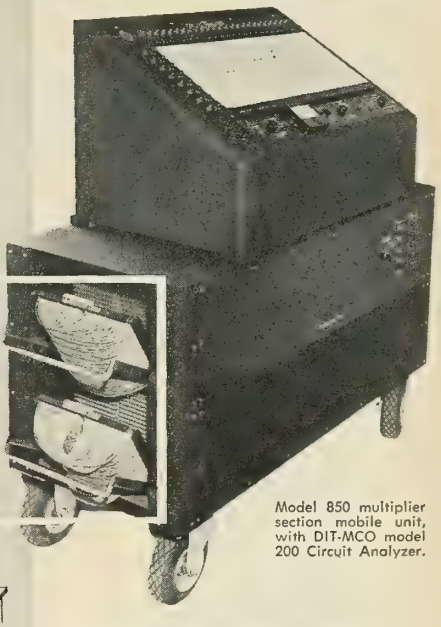
New Model 850

MULTIPLIER SECTION

featuring . . .

plugboard programming

new jumper-wire system simplifies test make-up and maintenance testing



Model 850 multiplier section mobile unit, with DIT-MCO model 200 Circuit Analyzer.



Now! In one operation at his desk, planner can design circuitry, layout matrix chart and jumper plugboard to conform to test sequence.



Now! Thorough, periodic maintenance tests can be made quickly and economically throughout the life of any airplane or missile.

Now! Test Modified Wiring Systems Without Altering Adapter Cables!

Do modified and improved electrical systems throw your testing section into a tailspin? Normally, it means existing test machinery (or the adapter cables, if DIT-MCO equipment is used) must be changed to conform to the circuit modifications. Here's how the new DIT-MCO plugboard system has solved that problem.

Circuitry can now be connected to the tester by the most convenient point-to-point method. Connecting wires (adapter cables) do not have to conform to any pattern. The testing sequence is programmed, quickly and easily, on the portable plugboards. Any subsequent circuit modifications are also handled on the plugboards . . . without changing existing adapter cables.

This is just one advantage offered by this new development. Write for full details on how DIT-MCO can help solve all your test problems.

Write today for complete information:

ENGINEERS:

DIT-MCO needs executive calibre sales and design engineers *right now!* Excellent opportunity with respected organization *on the move.* Work with key men in aircraft and missile industries. Write today!

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Electronics Division

Box 04-28, 911 Broadway
Kansas City, Missouri

Partial List of DIT-MCO Users:

Bell Aircraft Corporation, Texas Div. • Bendix Aviation Corporation, Sidney, New York • Boeing Airplane Company, Seattle, Washington and Wichita, Kansas • American Bosch Arma Corporation • Douglas Aircraft Company, Tulsa, Oklahoma • Fairchild Aircraft Division • Goodyear Aircraft Corporation • Martin, Baltimore • Naval Ordnance Laboratory, White Oaks, Maryland • Northrop Aircraft, Inc. • Motorola, Inc. • Temco Aircraft Corporation • Trans World Airlines • Convair • Chance Vought Aircraft • Servomechanisms, Inc. • Radio Corporation of America • Pacific Mercury Television Mfg. Corp.

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potted in an anodized aluminum case. The Crescent Engineering and Research Co.

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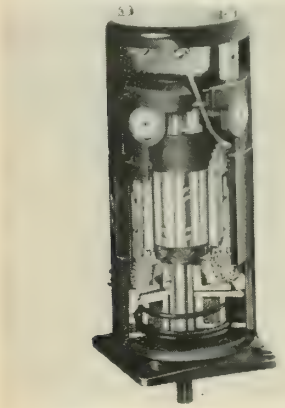
ACCELEROMETER

Genisco, Inc. is marketing an improved Model GLH accelerometer for missile flight and fire control systems. Weighing from 2 to 2.5 lbs. depending on G rating, the potentiometer-type instrument is available in ranges from ±IG to ±80G, or up to ±30G with reduced damping. Operational life is said to exceed 3 million cycles. Dimensions: 3.40 x 2.40 x 3.12 in.

Circle No. 203 on Subscriber Service Card

LIGHTWEIGHT MOTORS

Lundy Manufacturing Co. has unveiled a series of lightweight, fractional horse-



power motors rated from 1/20th to 1/8th hp and weighing from 15 to 22.5 oz. Designed for 26-volt operation, the Lundy motors feature an electromechanical brake, integral radio noise filter and nearly flat brush pressure characteristics made possible by use of a new brush rig construction.

Circle No. 234 on Subscriber Service Card.

MANIFOLD VALVES

Robbins Aviation has developed an aluminum three-valve housing having five ports for use in air distribution boxes. It is adaptable to applications over a range extending from high vacuum to pressures of 3,500 psi.

Valve features finger-tip control for all pressures. Construction of manifold is such that any or all of its valves can be overhauled without disturbing the plumbing. Valves are company's standard type using plastic seats and O-rings for sealing.

Circle No. 235 on Subscriber Service Card.

HIGH TEMPERATURE MATERIALS

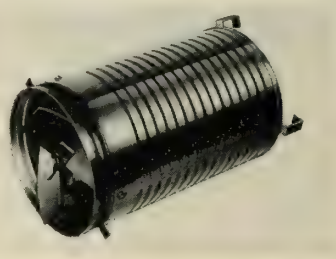
Haveg Industries, Inc. has introduced two new materials called Rocketon and Missileon for high temperature uses in rocket and missile construction. Basic make-up is a high melting silicate with an organic binder.

Among current uses cited by Haveg are: blast tubes for temperatures approaching 8,000°F; motor cases; flame reflectors and special insulating components. Company states that up to 17 parts in one rocket are of molded Rocketon.

Rocketon is said to have a compressive strength of 15,000 psi, tensile strength of 6,000 psi and ultimate shear of 9,500 psi. Respective figures for Missileon are 16,000; 6,000 and 10,500 psi. Density of both is 0.061 lbs. per cu. in.

Company states new compounds may be fabricated in parts as small as ½ in. dia. yet one-piece, field-fabricated sections have measured 205 ft. tall weighing 42,000 lbs.

Circle No. 236 on Subscriber Service Card.



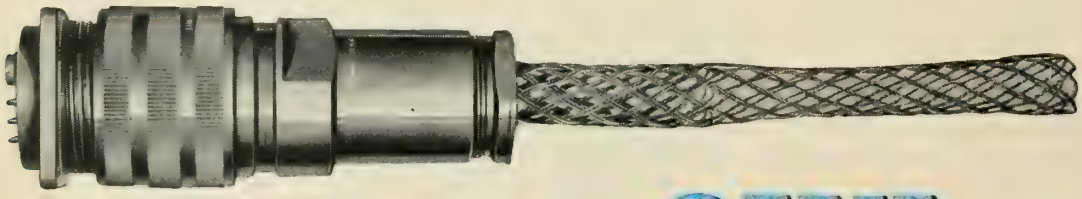
POWER ABSORBER

An electric power absorber marketed by Sun Electric Corp. and used in Army's *Redstone* and Air Force's *Snark* missile programs is said to replace 21 500-watt stick resistors while occupying only 1/25th the space they normally would require.

The power absorber is essentially a small cylinder in which air is drawn through circumferential casing slots over specially-designed, V-section ribbon resistors.

Unit operates at 13,500 watts continuous duty and weighs 1 lb. per kw absorbed. Space requirements total ½ cu. ft.

Circle No. 237 on Subscriber Service Card.



Presenting the New QWL

Bendix ELECTRICAL CONNECTOR

A HEAVY-DUTY WATERPROOF POWER AND CONTROL CONNECTOR FOR USE WITH MULTI-CONDUCTOR CABLE

This new QWL Bendix* Electrical Connector was designed for and is being used principally on ground-launching equipment for missiles and ground radar equipment.

Obviously, for this important type of service only the highest standards of design and materials are acceptable.

That's why it will pay you to specify the Bendix QWL Electrical Connector for any job that requires exceptional performance over long periods of time.

QWL outstanding features:

1. It combines the strength advantages of machined bar stock aluminum with the shock-resistant qualities of a resilient insert.
2. A modified, double stub thread provides for speed and convenience in mating and disconnecting and the special tapered cross-section thread design resists loosening under vibration. The threads can be easily hand cleaned if contaminated by a substance such as mud or sand.
3. An Alumilite 225 hard anodic finish is used which gives a case hardening to the aluminum surface. This finish offers outstanding resistance to corrosion and abrasion.
4. The cable-compressing gland used within the cable accessory accomplishes both a firm anchoring of the cable and effective waterproofing for multi-conductor cables. Neoprene sealing gaskets are used at every joint to insure a watertight connector assembly.
5. The cable accessory is designed to accommodate a Kellems stainless steel wire strain relief grip for additional cable locking.
6. A left-hand thread is used on the cable accessory to prevent inadvertent loosening.
7. High-grade copper alloy contacts are used which provide for high current capacity and low voltage drop. The famous Bendix closed-entry socket is used for contacts sizes 12 and 16.

*TRADEMARK

SCINTILLA DIVISION OF Bendix
SIDNEY, NEW YORK

Export Sales and Service: Bendix International Division, 205 East 42nd St., New York 17, N.Y.
Canadian Representatives: Aviation Electric Ltd., 200 Laurentien Blvd., St. Laurent, Montreal 9, Quebec

new product briefs

GREER HYDRAULICS, INC. has developed a linear actuator test stand said to achieve an accuracy within ± 1% in testing actuators at loads ranging from 50 to 5,000 lbs. Device is equipped to time actuator travel in inches per second and, by means of a dynamometer, to measure torque of screwjacks up to 60 lb. in.

Circle No. 225 on Subscribers Service Card.

EXPANDED LINE of flexible, polyethylene "Caplugs" for protection of ports or threaded fittings on delicate valves or instruments has been introduced by Protective Closures Co. Literature available.

Circle No. 226 on Subscribers Service Card.

CLAMP LINING for aircraft and missile installations introduced by Joclin Manufacturing Co. employs an asbestos wire-reinforced strip impregnated with Teflon. Joclamp lining operates at temperatures from —300° to 500°F and is said to resist damage from hydraulic fluids, oils and corrosive fuels.

Circle No. 227 on Subscribers Service Card.

RUSSELL MANUFACTURING CO. is producing an instrumentation tape woven with Fiberfrax, a new ceramic fiber developed by The Carborundum Co. Tape is wired to signal areas of high radioactivity when applied to atomic reactors and plumbing. Special zirconium adhesive used to affix tape is said to withstand temperatures up to 3,000°F.

Circle No. 228 on Subscribers Service Card.

TASK CORPORATION is marketing a new line of lightweight, high-performance induction motors for power outputs from 10 watts to 1,000 hp. Designs feature low weight to power ratios—a typical model weighing 4.8 lbs. is rated at 6½ hp at 24,000 rpm, 3-phase, 208 volts, 400 cycle.

Circle No. 229 on Subscribers Service Card.

ENVIRONMENTAL CHAMBER. A 5-cubic foot capacity environmental test chamber marketed by Mantec, Inc. is rated to drop temperatures from ambient to —65°F in five minutes and raise to 400°F in 10 minutes. Unit has 100 lb. dry ice capacity and is said to maintain temperature within —2°F over range from —100°F to 400°F. Overall dimensions are: length—22½ in., width—32 in. and depth—24 in.

Circle No. 230 on Subscribers Service Card.

SCINTILLA CONNECTOR. New SR type rack and panel electrical connector introduced by Scintilla Division, Bendix Aviation Corp. incorporates a solid shell and resilient insert to facilitate pressurization and provide maximum protection against vibration. They are rated for operation from—0° to 250°F.

Circle No. 231 on Subscribers Service Card.

TEFLON ENCAPSULATED, color coded flat cable for aircraft and missile electronics has been introduced by Miljan, Inc. Wire sizes range from 16 to 26 gauge and cables are fabricated with any number of wires up to a maximum of two inches in width.

Circle No. 232 on Subscribers Service Card.

ENVIRONMENT RESISTANT electrical connectors announced by The Pyle-National Co. are said to be impervious to water, moisture, oil, pressure, vibration and shock. Connectors conform to Spec. MIL-C-5015B. Literature available.

Circle No. 233 on Subscribers Service Card.



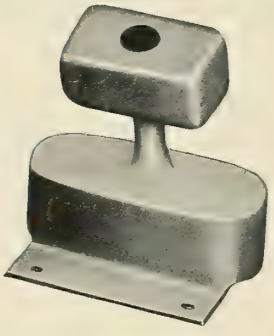
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CASE IN POINT!



FREEDOM OF DESIGN

This magnesium rudder component on a jet bomber consists of two hollow rectangular chambers joined by a tube. A wall thickness of 0.08" is uniformly maintained, proving that extensive areas of thin section and complex curvature can be investment cast without resort to joining.



FREEDOM OF ALLOY SELECTION

In order to increase the strength and creep resistance of this jet engine strut, the material specification was changed from stainless steel to a special low alloy steel. Investment casting offers this freedom in choice of alloy at little or no extra cost.

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"PIONEERS IN INVESTMENT CASTING"



INDUSTRY SPOTLIGHT

By Joseph S. Murphy

Complex Computers For Missiles

The electronic computer, virtually an inseparable ingredient in the nation's missile and rocket program since its development, is shaping a new giant in U.S. industry.

This year, according to the Assn. for Computing Machinery, total computer sales and rentals will reach the $250 million mark. And this does not include the special purpose, one-of-a-kind variety of computer that is not commercially available for lease or sale.

ACM's forecast came during the recent Western Joint Computer Conference in Los Angeles. At that session, eight of the country's leading computer producers gave this round-up report on today's equipment, tomorrow's prospects:

International Business Machines Corps.—STRETCH computer, slated for Atomic Energy Commission projects and due for completion by 1960, will be about 30 to 40 times faster than present computers. It will multiply and add numbers at rates up to one million items per second.

Remington Rand Univac and Philco Corp.—Reviewed their respective development of "desk size" computers which use magnetic amplifiers and transistors instead of vacuum tubes. Units consume no more electricity than four 100-watt light bulbs, and although now intended for scientific applications, developments for commercial use are anticipated.

National Cash Register Co.—announced its extensively transistorized computer designed for such commercial use.

Datamatic Corp.—Stated its Datamatic 1000 computer will store nearly four billion decimal digits and transfer these in the computer at a rate of 60,000 per second.

Logistics Research, Inc.—Reported its Alwac 800 can store up to six million decimal digits and gain access to groups of 12 of these digits in 40 one-millionths of a second. First Alwac 800 is slated for Federal Reserve Board in Washington.

Radio Corp. of America—Described its Bizmac II as a large-scale business data processor fitted with many forms of memory devices and especially designed for maintenance of business files. It is a modified version of Bizmac I used by Army Ordnance for inventory control. Electro Data Division, Burroughs Corp. said the Datatron computer will permit storage of 200 million decimal digits. Its system has been programmed to maintain a 200,000 item file for inventory control operations.

One of the better examples of the missile industry's efforts to get the most out of present-day computer equipment is a "do-it-yourself" program recently announced by Lockheed's Missile Systems Division.

MSD has set up a special course to qualify employes on the use of its IBM 650 computers. After 12-hours instruction, they are turned loose to use the equipment to solve mathematical problems as they arise.

The training is given on company time and the only prerequisite to the instruction is a knowledge of algebra.

Lockheed feels this approach will ease the workload of professional programmers on the staff of E. K. Fisher, head of its mathematics and computer service department at the MSD Van Nuys, Calif. plant.

Key to the "do-it-yourself" computer approach, according to Lockheed, is the development by IBM of a new simplified coding technique called SOAP (symbolic optimum assembly programming).

This technique makes it possible for the novice to write actual equations on his coding sheet, instead of the complex system of address numbers normally used to locate information within the machine.

In the Lockheed system, the engineer will first state his problem as an equation, then draw up a flow chart or analysis of the problem as a series of computer equations. He fills out a coding sheet from which a computer key punch operator takes instructions.

Next, he checks answers against a test case, for which he knows the answer, to locate possible errors. As part of the instruction course, he is taught how to diagnose answers and trace errors should they turn up. ★



Lockheed Computer Chief E. K. FISHER instructs missile engineer, MRS. FLORINE CAIN, on workings of IBM 650 computer. After 12 hours training, Missile System Division engineers program their own problems as part of "do it yourself" computer approach.

GE Gets TV Contract For Patrick AFB

General Electric Co.'s Technical Products Dept. has received an Army Signal Supply Agency contract to produce a closed-circuit color TV system for observing and tracking missiles at Patrick AFB, Fla.

A GE spokesman said the system will be used by Army observers for close-up viewing of launching operations and for tracking up to a possible 100,000 ft. altitude. Use of color TV is designed to give engineers valuable data on flight characteristics by observation and analysis of rocket motor flame characteristics at takeoff.

The new system is scheduled for delivery in May. Although the dollar value of the contract was not disclosed, it is believed to approach the high end of the estimated $25,000 to $100,000 range of price tags prevailing for color TV system ranges.

R-W Acts to Speed Test Data on ICBM

The Ramo-Wooldridge Corp., technical strategist in the Air Force's Ballistic Missile Program, has set out to speed the analytical side of missile testing to keep pace with advances.

A new facility unveiled this month by Ramo-Wooldridge is designed to do just that. Its aims—quick and accurate reduction of telemetered test data; more rapid analysis.

The R-W installation designed and built by its Electronic Instrumentation Division, will be operated by its Guided Missile Research Division.

Emphasis throughout its development was keyed to flexibility, according to R-W officials. Equipment now installed in the data reduction center can be quickly interconnected into circuits which can reduce any of a variety of input signals into forms required for engineering analysis. Provision for addition of new equipment is "built-in" should improved techniques become available.

A wide selection of equipment in the center has been united for flexibility by routing all circuits through a central "patchboard" control panel. This permits engineers to pre-wire circuits that will link together all units needed to process a specific piece of missile test data.

Output equipment is equally as flexible. It can produce graphic records for study by engineers, magnetic tape recordings for analysis in the computing center, or can feed signals directly into vibration analysis equipment in the data reduction center.

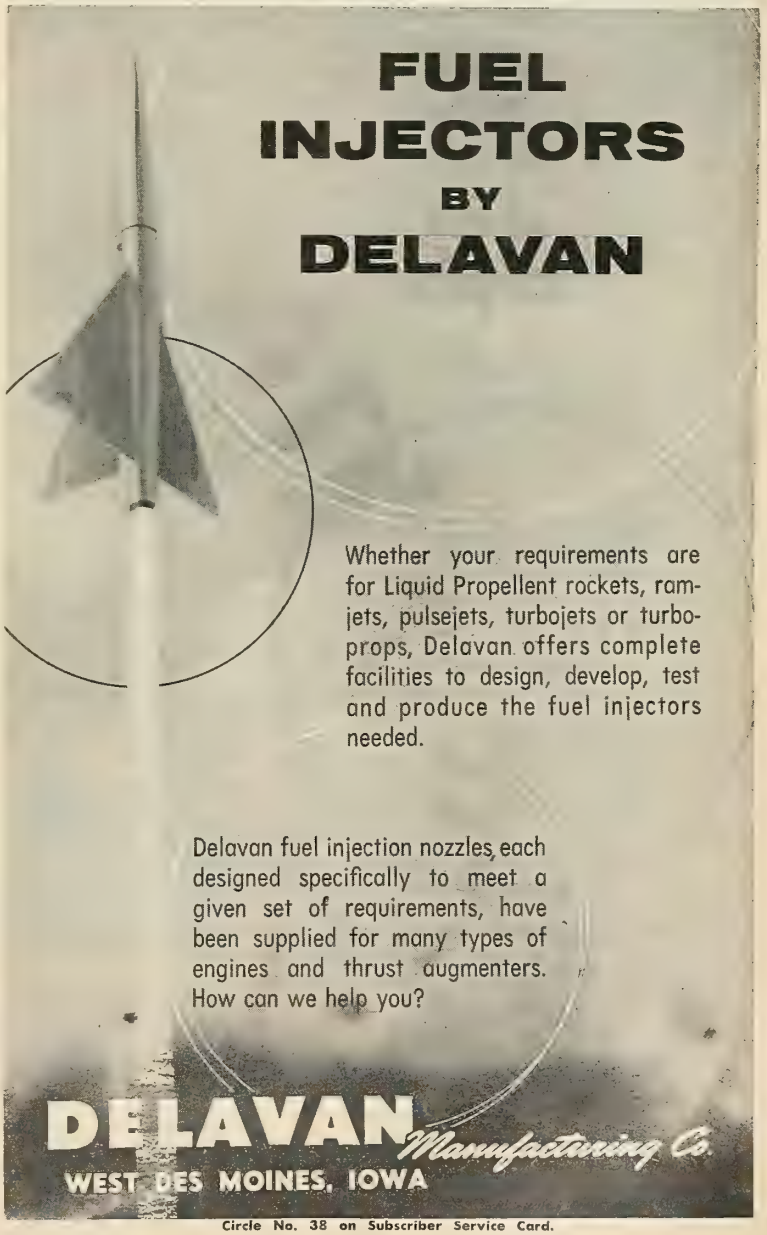
Typical of the versatility of the entire installation is the variety of equipment in the vibration analysis section alone. It includes a Davies automatic wave analyzer, a Hewlett-Packard wave analyzer, a Kay vibralizer, a specially assembled half-octave filter bank plus a special correlation function computer developed by the R-W Electronics Research Lab.

All units are assembled in modules with space and power supply provided in the overall center for 50 modules. To date 31 positions are occupied.

In the plan for the future are the addition of other devices to speed missile test data into engineering answers. They include equipment for time coding and decoding, automatic data search, pulse code modulation telemetering decommutation, data linearizing, Doppler data processing and other specialized requirements.

Douglas Divisions to Share Thor Engineering Work

Douglas-Santa Monica Division has subcontracted a portion of engineering for the Air Force *Thor* intermediate range ballistic missile to Douglas-Long Beach Division. Project coordinator on Thor at Long Beach will be W. W. Miller.



Circle No. 38 on Subscriber Service Card.



NEW

Trans-Sonics*

"TAPE-ON" SURFACE TEMPERATURE RESISTORS for Temperature Telemetering

- NO THICKER THAN A PIECE OF TAPE
- OUTPUT UP TO 5 VOLTS WITHOUT AMPLIFICATION
- AVAILABLE IN VARIOUS RANGES FROM −300° to +400°F.
- RESISTANCE CHANGE OF 100 OHMS OVER SPECIFIED RANGE
- NO HOLES TO DRILL — QUICK AND EASY "TAPE-ON" INSTALLATION

Trans-Sonics Type 1371 "Tape-on" Surface Temperature Resistors are precision resistance thermometers with a platinum resistance winding as the sensing element. These resistors which are no thicker than a piece of tape may be applied to *any surface* whose temperatures are to be measured. In a commutation circuit, they modulate standard telemetering transmitters without amplification. The new Type 1371 "Tape-on" Surface Temperature Resistors may be added to an installation using other Trans-Sonics temperature transducers without any further circuit modification. Each resistor is furnished with 6" long fibreglas-covered constantan leads. Write for Bulletin 1371 to Trans-Sonics, Inc., Dept. 9.

*Reg. Trademark

SPECIFICATIONS

SIZE: ¼" x 5/16"

Accuracy: ±2% of full scale range

Precision: ±0.5% of full scale range

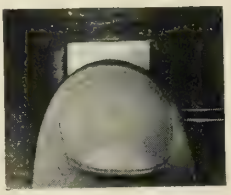
Maximum Continuous Current: 20 ma rms (averaged over 1 second)

Environmental Operation Conditions

Vibration: 1" double amplitude, 0 to 22 cps ± 25g, 22 to 2000 cps

Shock: 100g in any direction, per paragraph 4.15.1 of MIL-E-5272A (10 milliseconds shock)

INSTANT INSTALLATION



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For Transducers, See Trans-Sonics

Trans-Sonics, Inc.

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industry briefs

REACTION MOTORS, INC. paid 74% of its vendor/subcontractor dollar volume to 1,500 small business firms during last six months of 1956. Payments to small business totaled $3,082,000 of overall $4,182,000 spent by RMI.

FINN AERONAUTICAL DIVISION, Hawthorne, N. J. producer of combustion liners and flameholders of *Navaho* missile's Curtiss-Wright ramjet engines, has doubled facilities to 20,000 sq. ft.

MICRODOT, INC., builder of microminiature coaxial cables and connectors, has moved to new quarters at 220 Pasadena Ave., So. Pasadena, Calif.

SOLAR AIRCRAFT CO., San Diego, has received a $2 million contract from Hughes Aircraft Co. to produce *Falcon* missile airframes.

TUCSON INSTRUMENT CORP., new aircraft and missile electronics firm located in Tucson, Ariz. has commenced manufacture of potentiometers and electronic test equipment. President and treasurer is F. R. Perier.

G. M. GIANNINI & CO., INC. reports 1956 sales of $9,510,091, up 47% from $6,436,330 in 1955. Net earnings were $339,521 against $290,787 in 1955.

REACTION MOTORS, INC. has shifted its Los Angeles offices to larger quarters at 10835 Santa Monica Blvd. Office provides joint representation for RMI and Olin Mathieson Chemical Corp. and is headed by J. M. Rogers.

RHEEM MANUFACTURING CO. has commenced operations in an enlarged electronics research laboratory and production facility at 7777 Industry Ave., Riveria, Calif.

SPERRY RAND CORP. will build a $2 million plant at Clearwater, Fla., to specialize in research in microwave physics and the development of advanced radar and missile instrumentation. New division will be headed by E. J. Venaglia and will commence operations with a staff of 150 scientists and technicians.

BELL AIRCRAFT CORP. has received a $405,000 facilities contract from Air Materiel Command in its GAM-63 *Rascal* missile program.

GILFILLAN BROS., Los Angeles, has received a $2,877,000 contract to conduct a design improvement study of the ground guidance system for Army's Firestone *Corporal* missile.

GOODYEAR AIRCRAFT CORP. plans construction of a 20,000 sq. ft. addition to its rocket component production and development facilities at Akron.

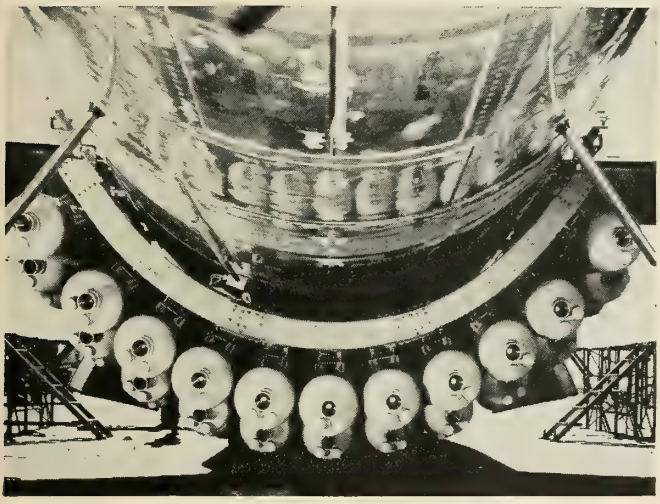
THE FIRESTONE TIRE & RUBBER CO., Los Angeles, has been awarded a $1,756,846 contract to design and build a guided missile stowage and launching system.

KAMAN AIRCRAFT CORP. is forming a Nuclear Division to engage in systems analysis and research in the fields of nuclear ordnance and propulsion. Group will be located at Albuquerque, N.M. under v.p. and general manager, Dr. K. W. Erickson, former chief of experimental weapons research for Sandia Corp.

THE EDO CORP. has received a $2,188,200 Navy Bureau of Aeronautics contract to build an undisclosed number of missile launchers and pylons.

Advantages you get with Phillips 66

SOLID ROCKET PROPELLANTS



The M15 JATO loaded on Boeing B-47 The first of its kind to meet rigid Air Force performance tests. (Boeing Airplane Company photo)

At the Phillips operated Air Force Plant 66 near McGregor, Texas, there are extensive facilities for development, testing, and manufacture of rocket propellants. Consult Phillips highly competent scientists and engineers about your specific propulsion problems.

- *LOW COST.* Phillips family of solid propellants for rockets is made from readily available petrochemical materials, such as ammonium nitrate, synthetic rubber, and carbon black.

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- *WIDE TEMPERATURE RANGE.* These rockets operate successfully from –75 F to 170 F.

- *INSENSITIVE TO DETONATION* by impact or explosion. Exhaust gases are noncorrosive and relatively low in temperature.

- *STORAGE.* Phillips 66 propellants can be stored for long periods of time without deteriorating.

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Bartlesville, Oklahoma

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Gyro Flight Stabilizers
Navigation & Stabilization Systems

DIVISION OF AMERICAN-STANDARD

Circle No. 21 on Subscriber Service Card.

Industry Highlights



By Fred S. Hunter

Interesting figures—The Douglas Aircraft Co.'s annual report shows missile sales in 1956 amounted to $140 million, and adds that orders for missiles and related equipment comprised approximately 16% of its backlog at the start of fiscal 1957. This translates into something above $170 million since Douglas reported a total backlog of $2,209 million and explained this was divided almost equally between military and commercial business. The Air Force recently revealed $67 million as the amount of current *Thor* ICBM contracts, leaving something in excess of $100 million in other missile work at Douglas.

•

More interesting figures—Lockheed Aircraft Corp. reports annual sales rate of its Missile Systems division now betters $70 million, and then goes on to stagger the imagination a bit by pointing out this is 13% greater than that of the entire air industry 20 years ago. In two years time, Lockheed's missile division multiplied its sales seven times, quadrupled its work force (now approximately 5,000) and more than doubled plant area in use or under construction (almost one million square feet.)

•

Still more interesting figures—J. R. Dempsey, general manager of Convair-Astronautics, quotes numbers to show missiles make more jobs. For the ICBM *Atlas*, Convair-Astronautics is scheduling employment of 8,000 workers. These will require 18,000 more in support work. For an airframe program of comparable scope, 8,000 direct wage earners would require only 11,000 more in supporting jobs. Astronautics, last year, spent more than $10 million with 330 suppliers in the San Diego area and $30 million with 894 suppliers in the Los Angeles area. They'll get more this year.

•

Not everyone seems to have been aware North American Aviation's Air Force contract for development of the *Navaho* was a three-stage affair. First stage was the turbojet X-10 test vehicle. Second stage was the intermediate XSM-64, with ramjet engines and a booster. Third stage is the long-range XSM-64A. The recent contract termination involved the intermediate stage XSM-64, with remaining funds and materials from this project transferred to the long-range XSM-64A, which continues with 1957 funds. Speculation over ultimate fate of the missile centers around the fact no money was earmarked for it in fiscal 1958 funds. But most people think 1958 money will still be budgeted for continuation of the project, so don't be in a hurry to write it off.

•

"Premium apparatus!" That's Lee Atwood's term for the electronics equipment the Autonetics division of North American is producing. A sample—the new CP-226 all-transistor digital computer, which weighs only 200 pounds and measures a mere six cubic feet, but will do everything, we're told, that an IBM 701 will do, only slower. Cost of the new machine is approximately $100,000. Autonetics envisions market possibilities for 3,000.

•

Berkeley division of Beckman Instruments, counting up, found 77 companies in the analog computor field in which it is active. Not all are turning out complete systems. Some make only components. But they have to be considered as possible competitors any time a request for bids is tossed out. Biggest analog plum up for grabs recently was a one-and-a-quarter-million-dollar job for the Glenn L. Martin Co.



This scientific pioneer is Dr. G. K. Wehner, designer of the space chamber which he uses here to determine the "sputtering" or disintegration rate of molybdenum under bombardment from atoms moving at 25,000 m.p.h., 200 miles above the earth.

What happens to metals at 25,000 m.p.h. 200 miles up?

General Mills scientists are finding some of the answers to this question, which bears directly on space ships and man-made satellites.

Their findings indicate that materials to be sent into space must possess properties not found in today's ores and alloys. Since few new metals remain to be discovered, they conclude that present ones must be given new properties to cope with the heat barrier and to keep vehicles from disintegrating under particle bombardment.

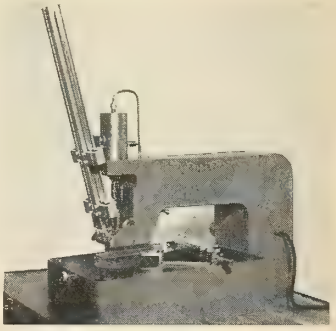
The study of metals in space flight represents but a single phase of General Mills' over-all program of advanced exploration in theoretical and developmental physics.

Findings in this "research for tomorrow" are being translated regularly into practical applications for industrial and military use today. If you have product or production problems, you can profit from these applications, and from our high-level production facilities.



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From General Mills' creative research and precision manufacturing come machines for industry to use today—machines such as *Autofab*, for near-automatic assembly of electronic components on printed circuit boards.

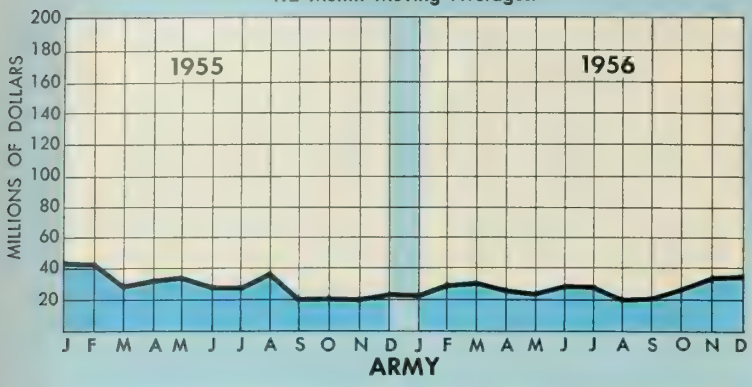
MECHANICAL DIVISION OF General Mills

CREATIVE RESEARCH AND DEVELOPMENT + PRECISION ENGINEERING AND PRODUCTION

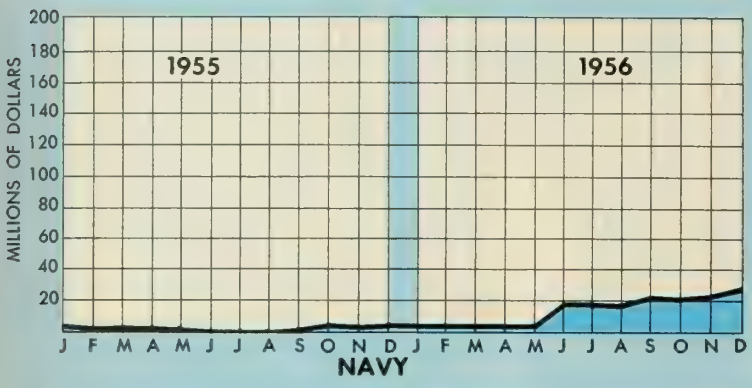
INDUSTRY BAROMETER

GUIDED MISSILE OBLIGATIONS INCURRED

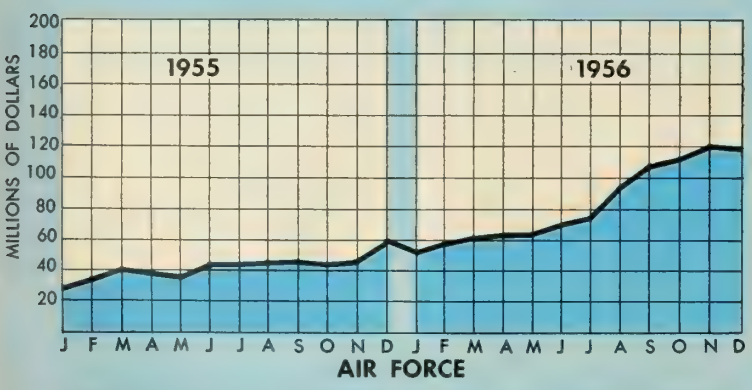
(12 Month Moving Averages)



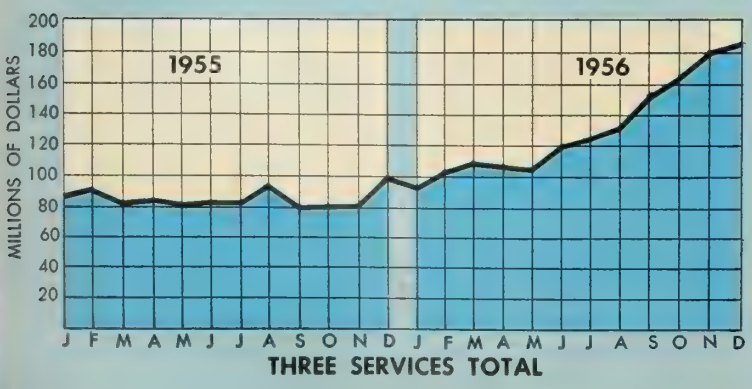
ARMY



NAVY



AIR FORCE



THREE SERVICES TOTAL

The twelve-month moving averages illustrated (see November 1956 "Industry Barometer") point out the rising rate of obligations for guided missiles during the current fiscal year.

Department of Defense average missile obligations have increased from $100,554,000 in December 1955 to $186,137,000 in December 1956, a jump of 85%.

Army guided missile obligations continue to fluctuate from month to month, but show a marked increase during November and December of 1956. The December '56 average obligations incurred ($36,251,000) represent an increase of 48% over December 1955 ($24,476,000).

Missile obligations incurred by the Navy reached a new high in December of '56 ($29,412,000). This figure is a 90% increase over December 1955 average obligations of $15,470,000.

The Air Force's average obligations show an upward trend during the first half of fiscal year 1957. December 1956 obligations ($119,940,000) increased 98% over December 1955 ($60,609,000).

Guided missile obligations incurred during the first half of fiscal year 1957 (July through December 1956) amounted to more than twice the money obligated for missiles by the Department of Defense during the first half of fiscal '56. From July through December $1,391 million were obligated, compared with $604 million in the previous year.

Direct obligations by the Department of Defense should average about $280 millions per month of the last six months of the current fiscal year (January-June 1957). This is based on the fact that total direct obligations for missiles are estimated at $3,071 million for fiscal year 1957. During the second half of FY 1957—based on current Pentagon thinking and money committed in the first half of the fiscal year, indications point to:

. . . Army missile obligations exceeding those of the first half, probably averaging about $83 million per month;

. . . Navy guided missile obligations decreasing over the first six months of fiscal '57, to an estimated $31 million per month for the six month period;

. . . Air Force obligations increasing; an average for the six month period of $166 million per month.

IBM Reports Income and Facilities Expansions

Year end report of the International Business Machines Corp. shows gross income as $734,339,780 compared to $563,548,792 for 1955. Net income after taxes was $68,784,510 which amounts to $13.10 on outstanding shares.

During the year, IBM said, the five-hundredth type 650 data processing machine, and the one-hundredth 700 series data processing machines were delivered to customers.

Facilities expansions noted were the new Kingston, N. Y. manufacturing plant for producing Sage computers, a 406,000 square foot plant and laboratory near Owego, N. Y., believed to be planned for production of Air Force BRANE navigation and bombing systems, and 96,000 more square feet of laboratory space at Poughkeepsie. N. Y.

Other new plans call for an engineering laboratory with 160,000 square feet in Kingston for work on SAGE and other defense projects.

A major new product that came out of the laboratories during the year was IBM's 305 RAMAC based on a new concept of random access accounting. Disc memory units can store 24 million digits of information.

Work is also underway on a large-scale computer being developed jointly by IBM and Los Alamos Scientific Laboratory of the AEC. The new computer will be between 100 and 200 times faster than any commercial computer in existence.

New Matador Contract

Air Materiel Command has awarded The Martin Co. a follow-on contract amounting to $1,527,981 for *Matador* TM-61B missile testing.

Talco is Building New Phoenix Facility

The Talco Engineering Co. of Hamden, Conn. has acquired a 2,000-acre plot near Phoenix, Ariz. for construction of testing and firing range facilities capable of handling cartridge-actuated and rocket devices.

F. G. Talley, Talco president, said the facilities also will be made available for evaluation of contractor-furnished and developed airborne equipment and systems.

Company plans to complete the

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The *Research Laboratory* is engaged in the study of gases and gas dynamics at high temperatures. We are interested in the phenomena accompanying the dissociation and ionization of gases and in the application of these phenomena. Future plans call for research in non-competitive fields for application to defense and commercial products.

If you are interested in genuine research activity and have related research experience, you will be interested in these opportunities:

Jr. Scientists — Degree in Physics or Aerodynamics, plus 0-2 years experience.

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To inquire about opportunities in the Research Laboratory, write or send resume to Robert M. Hale, Scientific and Professional Staff Appointments, Group 33.

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LIVE BETTER! The San Diego area offers you every advantage for delightful living. Warm and sunny climate the year around.

first phase of construction in July including a sled track, environmental testing laboratory, office, shop and storage buildings. Firm's operations in Connecticut will continue at an expanded level with the Phoenix site slated to handle qualification and production testing of the larger equipment it builds.

Among the latter is a new personnel rocket catapult developed for the Convair F-102 and TF-102. Company officials said development of versions of this system for other aircraft is currently in progress.

General Tire Nets $10.8 Million

General Tire & Rubber Co. netted $10,860,129 in 1956, a drop from $11,600,463 in 1955 despite a sharp increase in sales from $295,731,096 to $390,471,772 for the parent firm and its subsidiaries, including Aerojet-General Corp.

Although specific Aerojet sales for the year were not given in General's annual report, it was noted that they increased by 109% over 1955 and that its backlog now exceeds $500 million.

The report did, however, deal in considerable detail with the accomplishments of Aerojet during the year, highlighting these specific points:

Manufacture of more than 1,300 large solid-propellant booster rockets for guided missiles.

Production of 40,000 smokeless JATO units, 1,000 *Sparrow* missile powerplants, 3,500 *Nike* sustainer motors and several hundred large JATO units for medium bombers.

Development of a liquid propellant booster for the Boeing *Bomarc*, followed by successful *Bomarc* testing at Patrick AFB, Fla.

General Tire also noted progress on development of a solid propellant sustainer motor for the Martin *Bullpup* missile; a booster for launching the Chance Vought *Regulus* II; and, start of work on a new *Sparrow* engine using Aerothane as propellant for increased specific impulse.

In the R&D area, Aerojet developed the largest solid propellant powerplant ever used in any ballistic missile, the report disclosed. The unit was developed for the Army's Jupiter IRBM and, in October, testing began on a reduced-scale Jupiter rocket.

Also mentioned in brief was Aerojet's activity toward development of a new type of powerplant, an air-turbo-rocket. The engine was described as a high-speed, high-altitude powerplant combining the best features of rockets and ramjets.

An Announcement

OF FIRST IMPORTANCE TO EXPERIENCED ROCKET ENGINEERS AND SCIENTISTS

- *Reaction Motors initiating big new Research and Development Program*
- *Key spots offered to men who have already made a name for themselves in Rockets*

If you're one of the relatively few trained rocket men in America, your experience will pay off handsomely at Reaction Motors. The first rocket company in America, RMI is now entering its period of greatest expansion, a period that will see far-reaching developments in America's fastest-growing industry. Your participation in RMI's program during this crucial period is your best guarantee of leadership in the industry. In a job like one of those listed below you'll be strategically placed for both achievement and advancement.

1. Stress Engineer

Degree in engineering or applied mechanics. Required experience in mechanical design with emphasis on stress analysis: 3 years for an engineer, to 6 years for the senior engineer. Must be able to handle and/or supervise involved analyses—including the effects of dynamic forces, high temperature gradients and high pressure differentials—under conditions where light weight is vital.

2. Technical Planning Engineer (advance design)

Our technical planning group has an immediate opening for a qualified engineer with about 5 years' experience (mostly mechanical) in high-performance turborocket engine design. Experience with turborockets should be broad and should cover thrust chambers and turbopumps. Additional experience with turbojet engines is also desired, though not essential. Work will involve, determining future propulsion requirements, evaluating them, and creating designs for products to meet them.

3. Controls Engineers

Here, we are looking for men who will solve rocket propulsion problems by applying their knowledge of fluid flow theory, thermodynamics, servomechanism and information theory, analog simulation or statistical design techniques—The work includes designing valves and other control components; development of hydraulic, pneumatic and electrical feedback control systems and sequence control systems; analog simulation of single components and complete systems, including computer set-up and problem formulation; application of statistical design techniques to control situations.

4. Applications Engineer

Work involves technical liaison with military agencies and airframe industry to discuss requirements and determine applications for aircraft pumps, valves, ignition systems and related products. Must have sufficient technical experience to understand construction, operation and performance of power plants and be able to integrate with requirements of airframe engineers. Knowledge of military contracts and airframe industry desirable. This is a responsible opportunity in the aviation industry for a mature, ambitious man to age 45 who possesses imagination, initiative and ability to organize.

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More and more engineers are finding that a satisfying career can only be built around a full, rich family life. That is why Westinghouse-Baltimore stresses the advantages to the young engineer of coming to Baltimore. In the colorful new book, "New Dimensions," your family can get all the facts on this friendly city—its homes, schools, churches, social and cultural activities and its recreational facilities.

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SINCE 1886

GE Dedicates IBM-704 Facility

First computer installation of its kind has been inaugurated by the General Electric Co.'s Computer Department on the Campus of Arizona State College.

The center is equipped with an International Business Machines Corp. 704 computer that will be jointly used by GE and the College.

H. R. Oldfield, general manager of GE's computer department predicted at the opening ceremonies that present computer sales of $450 million annually would rise to over $1 billion by 1966.

Martin To Expand Denver Facility

Recently completed $10-million plant of The Martin Co. in Denver will undergo further expansion at a cost of $2 million. Plan calls for addition of an engineering laboratory, extension of the administration building and of the plant cafeteria.

Martin now employs 2,500 at the facility and expects this figure to double in 1958.

Ryan Sales Increase, Net Drops in 1956

Ryan Aeronautical Co., producer of the Firebee jet-powered target drone, showed a 19% decrease in net profit last year despite an increase from $41,527,770 to $46,998,925 in sales for fiscal year ended October 31.

Declining profit was attributed to high "make-ready" costs in early phases of new items production.

Ryan backlog, however, increased $17 million and now stands at $92 million. In addition to the Firebee production, president T. Claude Ryan cited missile guidance as one of three phases of aviation electronics work being carried forward by the company.

Boeing Gets New Plant For *Bomarc* Manufacture

Boeing Airplane Co. will take over a former Army Corps of Engineers plant for *Bomarc* missile and B-52 bomber production under a recent Army-USAF agreement.

Some 100,000 sq. ft. of the new plant will be used for Bomarc work along with 200,000 sq. ft. of its new Development Center now in the construction stage. Balance of the 347,000 sq. ft. Army plant will be allocated to B-52 manufacturing and will be fitted with eight spar and two skin mills.

Convair Astronautics Move to Begin in June

Convair Astronautics Division expects to begin shifting personnel into its new $40 million Kearny Mesa plant late in June. First building up will be the engineering laboratory.

Plan is to transfer employes as space and facilities become available, with the overall shift extending from June through December.

In July, Convair will partially occupy two office buildings, one for engineering and the other administration. Cafeteria, power and security buildings will also be completed about the same time.

Last building slated for occupancy will be the manufacturing plant expected to be completed in November.

Missile Sales Up At Lockheed

Missile Systems Division of Lockheed Aircraft Corp., in the two years since its formation, has increased its sales seven-fold, quadrupled its work force and more than doubled its laboratory, office and production space, according to Lockheed president Robert E. Gross.

Gross places present sales at about a $70-million annual rate. MSD now has 1,000,000 sq. ft. at facilities in Van Nuys, Palo Alto and Sunnyvale, Calif. and has started construction of a 3,200-acre test center in the Santa Cruz mountains.

Two Contracts Let For New Fuels Plant

Air Force and Navy last month awarded contracts totaling $71.5 million for construction of facilities to produce high energy fuels.

AF contract, issued by Air Materiel Command, went to Olin Mathieson Chemical Co. in the amount of $33.5 million for a plant to be located at Niagara Falls, N. Y.

Navy's award to Callery Chemical Co. is further advanced than that of USAF. Ground was broken early last month on a $38-million facility at Muskogee, Okla. and output of HiCal, a boron compounded high-energy fuel, is expected late next year.

Bomarc Contract In The Making

The Air Force and Boeing began negotiations early last month for the first volume production contract for the IM-99 *Bomarc* pilotless interceptor missile. Weapon will be manufactured principally in Seattle with support from

engineers

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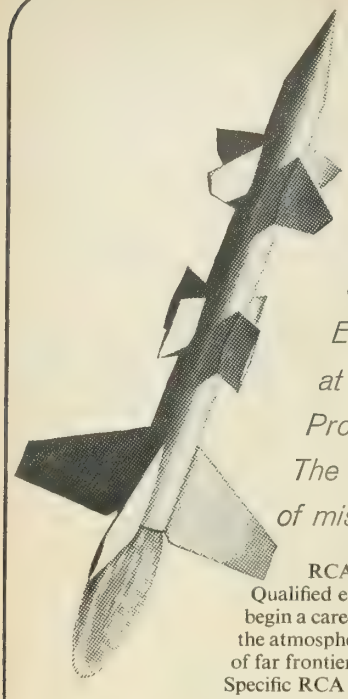
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RADIO CORPORATION of AMERICA
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Wichita. Boeing will utilize 100,000 square feet of an Army Corps of Engineers facility in the Seattle area for *Bomarc* work. The government-owned facility was made available by the Air Force after working out an agreement with the Army.

Hughes Adopts Work-Study Plan

Hughes Aircraft Co. has launched an engineer work-study program with three universities designed to provide full payment of college tuition and related expenses for undergraduate engineers it employs.

Hughes officials said the plan is expected to increase to 950 the number of part-time or full-time employes studying for degrees at company expense. The new plan extends the program outside of the company for the first time.

Schools associated with the program are Loyola Univ. of Los Angeles; Univ. of Southern California and Univ. of California at Los Angeles.

Temco Names Plant For Missile Work

Temco Aircraft Corp., known recipient of a Navy contract to design and develop the *Corvus* missile, has designated its Garland, Tex. plant for missile and drone production.

Before the *Corvus* award, Temco won a Navy competition to build the XKDT-1 rocket-powered missile target drone.

ACF-Erco To Build Missile Arming Units

Contracts for design and development of safety and arming devices for Air Force's Boeing *Bomarc* and Army's Chrysler *Redstone* missiles have been awarded by the Army to Erco Division of ACF Industries, Inc.

Three Missile Firms Get Rapid Writeoffs

Three rocket and missile firms—Aerojet-General Corp., Propulsion Research Corp. and Convair were on the most recent list of firms receiving rapid tax amortization of new facilities.

Aerojet was allowed 60% by Office of Defense Mobilization in certifying $417,740 for research and development facilities.

Accelerated tax amortization to Propulsion Research Corp., also for R&D facilities, amounted to $88,359 at 70%. The Convair certificate for R&D facilities: $17,022,000 at 60%.

Fruehauf Converts Missile Capacity

Fruehauf Trailer Co. is planning to convert the entire capacity of its Delphos, Ohio plant to handle increasing defense contract work, primarily missile ground handling and support equipment.

Company reports it now builds such equipment for six major missile types and is in design and prototype phases for a number of others.

Current projects are *Redstone, Regulus, Thor, Nike Matador* and *Ding Dong.*

Anadite Opens Plant at Hurst, Tex.

Anadite, Inc. of South Gate, Calif., specialist in chemical milling and finishing of aluminum, magnesium and steel, opened a new 20,000 sq. ft. plant at Hurst, Tex. on April 1. Firm will be called Anadite, Inc. of Texas and will employ more than 100.

New facility is situated on a 3-acre site and represents an investment of more thain $500,000.

Republic Gets ICBM Subcontract from GE

Republic Aviation Corp. Guided Missiles Division will build an undisclosed number of Convair ATLAS ICBM nose cone structural units under a $500,000-plus contract from General Electric.

Republic plans to handle tooling and heavy machining for the contract at its plant at Farmingdale, N. Y.

M-H Nets $22 Million Report Sales Up 18%

Minneapolis-Honeywell Regulator Co. reports an 18% increase in sales during 1956 to a record $287,944,462, up from $244,842,068 the previous year. Earnings were $22,463,657 compared to $19,278,648 in 1955.

Insurance Firm to Build Lockheed Missile Facilities

Prudential Insurance Co. has entered into an agreement with Lockheed Aircraft Corp. under which it will provide facilities costing about $14 million and lease them to Lockheed's Missile Systems Division on 25-year terms.

The deal is believed the first in which an aircraft company has used facilities provided by insurance companies as a means of preserving working capital.

In the Lockheed program, Prudential is acquiring title to 83 acres of the 275 owned by Lockheed at Sunny-



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vale, Calif. and also is taking a 99-year lease on a portion of the research laboratory ground at Stanford Industrial Park, Palo Alto.

Navy Orders *Talos* Missile

Navy has awarded Bendix Aviation Corp. a $27 million contract for quantity production of the ramjet-powered *Talos* surface-to-air missile. First *Talos* deliveries are expected in less than a year and are earmarked for two new missile cruisers—the *Little Rock* and *Galveston*—now undergoing conversion.

Northrop Sets Up Redstone Office

Northrop Aircraft has established an office at Huntsville, Ala. under A. A. Demetriou, former contract administrator of its Anaheim Division.

New installation will represent Northrop's subsidiary Radioplane Co. at nearby Redstone Arsenal.

Thiokol Acquires New Firm

Thiokol Chemical Corp. has acquired full control of National Electronics Laboratories of Washington, D. C. through an exchange of stock. It will operate the company as an independent, wholly-owned subsidiary under its existing name.

Republic Payroll Tops $1 Billion

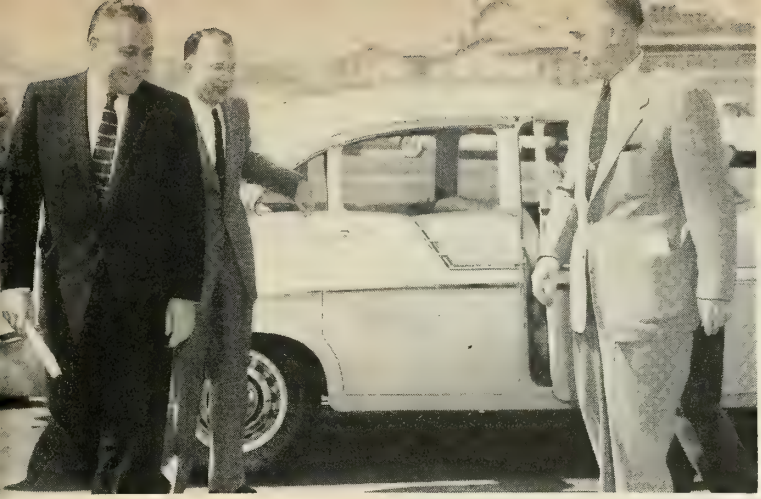
Republic Aviation Corp. builder of the *Terrapin* upper air research rocket, recently joined the ranks of aircraft manufacturing firms paying out $1 billion or more in salaries when its 1956 payroll reached $1,002,074,000.

Republic paid a year-end bonus of nearly $2 million to put it in the billion-dollar wage bracket for the first time.

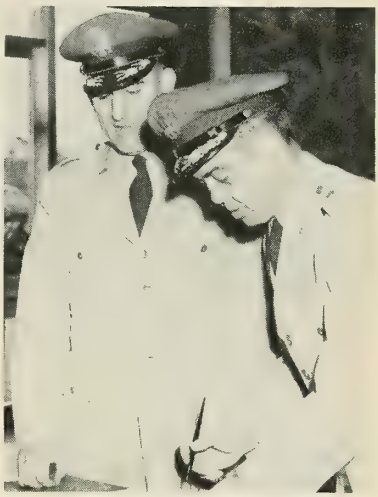
$19.5 Million Contract for Associated Products

Martin-Denver has awarded Associated Products Corp., subsidiary of American Machine and Foundry Co., a $19.5 million missile instrumentation contract, presumably for the *Titan* ICBM.

Simultaneously, AMF announced plans for a 28,000-sq. ft. plant expansion in El Monte, Calif. to be used for production and assembly of missile ground instrumentation and check-out equipment and an 18,000 sq. ft. structure at Englewood, Calif., for field engineering.



Dr. Louis G. Dunn, Vice President and Director, Guided Missile Research Division, The Ramo-Wooldridge Corporation, left; Dr. Dean E. Wooldridge, President and Treasurer, Ramo-Wooldridge Corporation and the Honorable Lyle S. Garlock, Asst. Secretary of the USAF for Financial Management arrive at the Western Development Division Headquarters to attend a briefing.



Col. D. F. Miller, left, and Brig. General Don R. Ostrander, register at the Western Development Division for a meeting with Maj. Gen. D. N. Yates, Chairman Guided Missile and Space Vehicle Committee.



Dr. Ralph W. E. Reid, Asst. Director, Bureau of the Budget, far left; Alvin O. Waggoner, Executive Secretary Ballistic Missile Committee, Office of the Secretary of Defense; Wreatham . Gothright, Asst. Director, Bureau of the Budget, sign in at the Headquarters of the Western Development Division while Capt. Dan Babcock looks on.

Maj. General B. A. Schriever and the Honorable Richard E. Horner, Asst. Secretary of the USAF for Research and Development discuss phases of Ballistic Missile research during a visit Sec. Horner made to WDD.



Dr. Clark B. Millikan, Acting Chairman Scientific Advisory Committee, left: Brig. Gen. D. R. Ostrander, Asst. Deputy Commander for Weapons Systems, ARDC, and Committee member George B. Kistiakowsky enter the WDD Headquarters building for a Committee meeting.





ARDC Information Director Col. Albert A. Arnhym, right, gets congratulations after receiving Legion of Merit from Lt. Gen. Thomas S. Power, ARDC Commander.

J. R. Dempsey, formerly program director of the ICBM Atlas project, has been named manager of Convair's new Astronautics Division. Other officers appointed are **K. J. Bossart,** tech. dir.; **Mortimer Rosenbaum,** chief engr.; **H. R. Friedrich,** asst. chief engr. for development; and **Krafft A. Ehricke,** asst. to the tech. dir.

Dale A. Lichty, senior vp, has been elected president of Hydro-Aire, Inc., succeeding **Homer H. Rhoads,** resigned.

Joseph Philipson has been appointed director of Atlantic Research Corp.'s newly formed Western Div. with headquarters at Pasadena, Calif. **Turner W. Ivey** has joined the Chemistry Div. in Alexandria, Va., where he will supervise junior engineers in the production of solid propellant rockets, and in further development of propellant production methods and processes.



LICHTY



DEMPSEY

Dr. L. L. Wheeler, formerly chief engr., has been appointed industrial relations vp of Sperry Gyroscope Co.

Dr. Robert P. Petersen, former dir. of nuclear research for Republic Steel Corp., was elected president of Applied Research, Inc.

Asst. Secy. of Defense **Frank D. Newbury** has been appointed to the newly created position of Asst. Secy. for Research and Engineering, with **William M. Holaday** as his Deputy.

R. L. Cunningham, asst. mgr. of the engineering personnel offices of both the Missile Development division and Autonetics, has been named mgr. of Missile Development division's engineering personnel.

Philip I. Chase, head of the materiel div., has been elected vp-manufacturing, and **Joseph Corie,** asst. to the executive vp, has been elected secy.-treas. of Radioplane Co.

James R. Lewis has been appointed dir. of public relations for The Ramo-Wooldridge Corp. Formerly senior staff asst. in the Guided Missile Research Div., he will continue special assignments on management problems and program information.

Three promotions have been announced by the U.S. Naval Air Rocket Test Station: **Irving Forsten** becomes chief engineer, **Frederick R. Hickerson** replaces Forsten as senior project engineer, and **John J. Canavan** goes from head of the Test Branch to head of Rocket Test Div.

Orrin C. Bowers has been appointed chief engineer of BJ Electronics, Borg-Warner Corp.

Alfred Finzel, former Chief of Structures for the Army Ballistic Missile Agency at Redstone Arsenal, has been appointed Project Engineer in Ramjet Design for the Wright Aeronautical Div. of Curtiss-Wright Corp.

James M. Jackson and **Dr. David S. Stacey,** formerly in charge of the Research Service Laboratories at the Univ. of Colorado, have been named director and technical dir. respectively of the newly formed Ball Brothers Research Corp. at Boulder, Colo. The corporation will conduct research in electronics, aerophysics, optics, servomechanisms, and other instrumentation.

Louis Bucalo has been promoted to asst. chief engineer at Specialties, Inc. and **F. P. Caruthers** has been appointed project engineer at the company's Syosset plant, L. I., N. Y.

Dr. Robert W. Buchele, formerly a faculty member of the UCLA School of Business Administration, has been named staff administrator for Northrop Aircraft's new executive development program.

O. A. Wright, staff engineer for Lockheed's Missile Systems Div., has been appointed engineering mgr. of Actuation Research Corp., Glendale, Calif.

Capt. Marshall B. Gurney (USN, ret.) has been named manager of the Govt. Relations Dept. at Raytheon Mfg. Co.'s Santa Barbara, Calif. laboratory.

C. M. Martenson has been elected vp and gen. mgr. of Hydraulic Research and Mfg. Co. Other company officials announced are: **S. A. Baker,** treas., and **J. R. Haber,** asst. secy. and treas.



FINZEL

missile literature

GYROS. Aeronautical Division, Minneapolis-Honeywell Regulator Co. has published a 28-page booklet containing specifications and variations of its major hermetic integrating, rate and cageable vertical aeronautical gyros.

Circle No. 109 on Subscriber Service Card

INFRARED DEVICES. Electronics Corporation of America has prepared an 8-page booklet describing infrared-sensitive lead sulfide photoconductors it produces for detection and guidance systems.

Circle No. 110 on Subscriber Service Card

INSTRUMENTS. Precision guidance and control instruments produced by Humphrey, Inc. are illustrated in 24-page catalog.

Circle No. 111 on Subscriber Service Card

LIQUID OXYGEN SWITCHES. Engineering Bulletin issued by Revere Corp. of America describes its series of liquid oxygen float switches designed to indicate or control liquid oxygen levels. Units weigh 4 oz., operate at temperatures from —320° to 200°F.

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MISSILE CONTAINERS. Specially designed containers for missiles, missile components and electronic equipment are described in 8-page brochure by Craig Systems, Inc.

Circle No. 100 on Subscriber Service Card.

HITEMP ALLOYS. Twenty-page booklet issued by The Carpenter Steel Co. gives engineering data and fabrication characteristics of ten high-strength alloys it produces for elevated temperature service in aircraft and missiles.

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SILICONE FLUIDS. Dow Corning Corp. offers a 4-page reference brochure outlining physical and electrical properties of all leading silicone fluids now commercially available.

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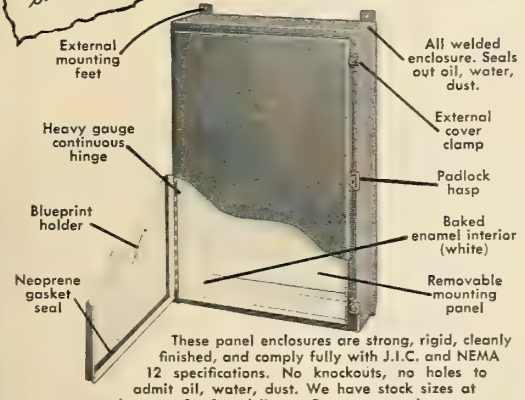
SEALED RELAYS. Four-page bulletin published by A'G'A Division, Elastic Stop Nut Corp. of America, describes hermetically-sealed, Agastat time delay relays.

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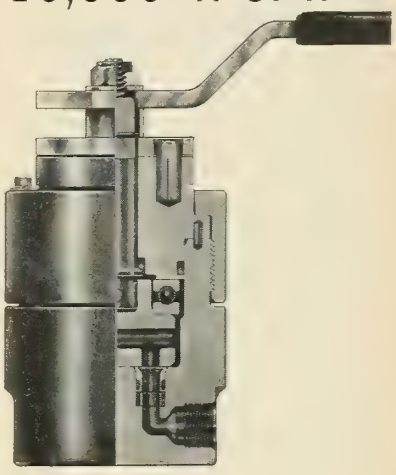
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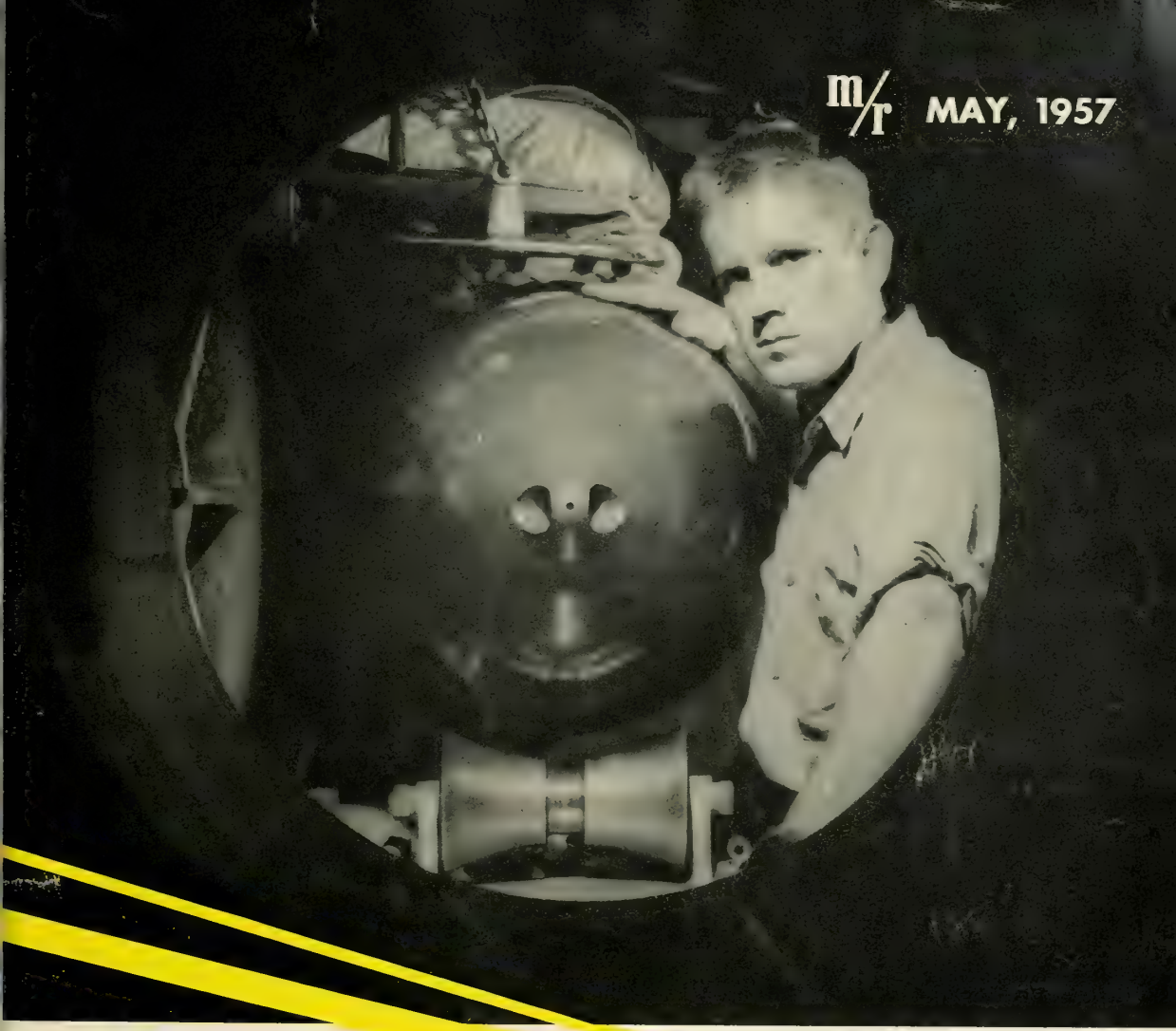
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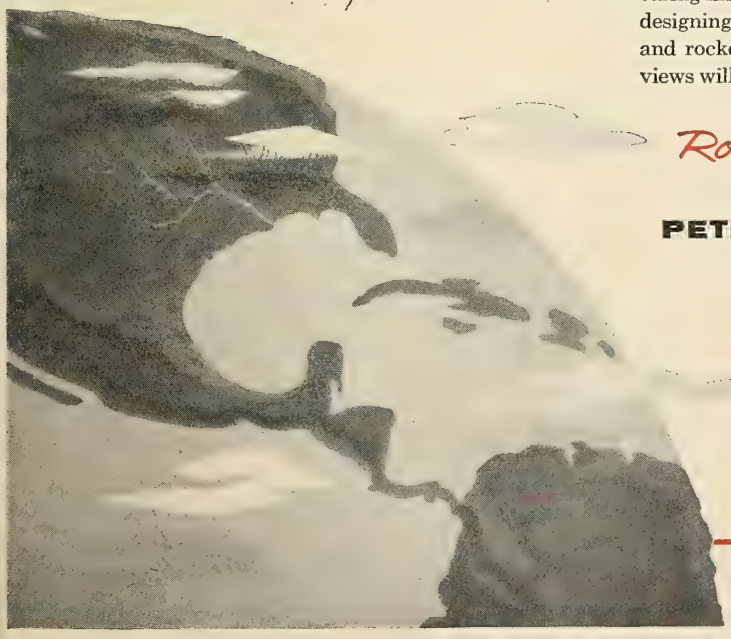
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Manned strato-balloon flights probe the mysteries of space

This is the Navy Project Strato-Lab balloon that set a new altitude record in a recent ascent at Rapid City, S. D. The fact that Commanders M. D. Ross and M. L. Lewis rose to 76,000 feet, the highest man has flown in a balloon, was incidental. Of far more importance was their demonstration that a light, comparatively inexpensive polyethylene balloon, with a gondola carrying its own atmosphere, is a feasible means of carrying human observers above the present ceiling of sustained powered flight. Manned flights to altitudes of 100,000 feet or more are possible today.

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Here R. G. Rickey (left), components specialist, discusses new accelerometer designs with E. V. Stearns, head of the Inertial Guidance Department.

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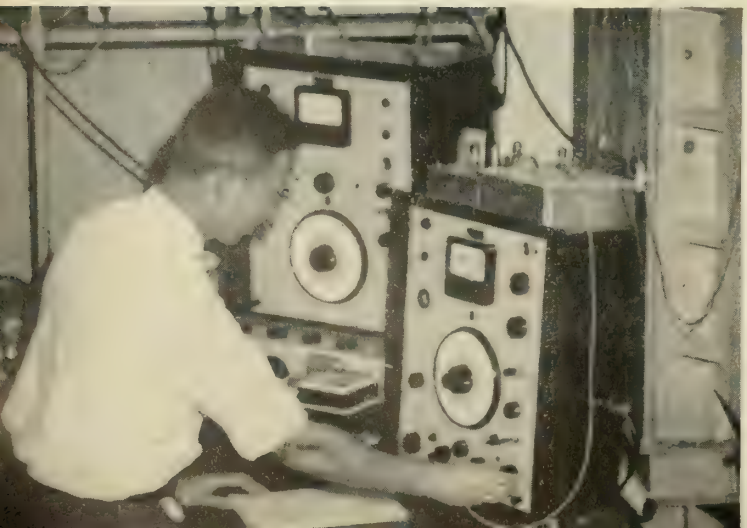
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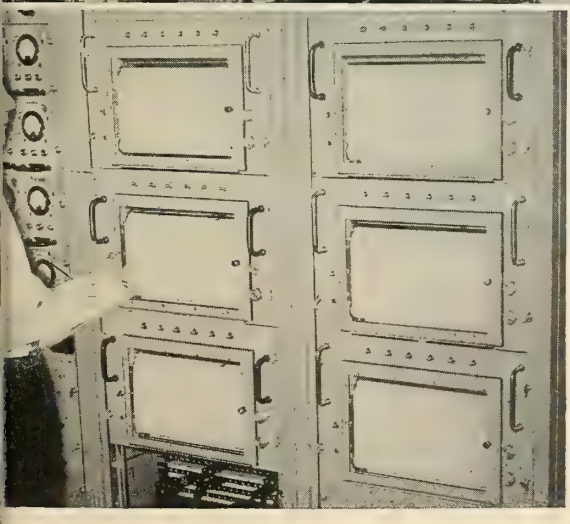
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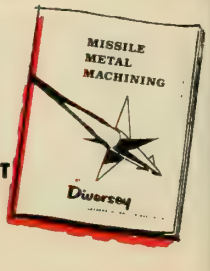
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Another Industrial Challenge

After having been convinced by Rear Admiral Rawson Bennett that the torpedo was the first truly guided missile, our managing editor recently decided to look into the possibility of publishing articles on underwater warfare.

It soon became apparent, however, that today's torpedo and underwater missile systems embrace a whole new technological and strategic undersea warfare concept and that the advances to date called not for just an article or two, but an entire issue devoted to the subject.

This eye-opener of an issue, which was made possible through the kind cooperation of the Navy, of its Bureau of Ordnance and their efficient officers and civilians of the Office of Public Information and Security Review, clearly shows the importance of a continued and meticulous effort on the part of our Navy and industry's missile men to maintain a number one position in this field.

The reason for this is the Russian submarine threat. Naturally, Russia's answer to our overseas SAC bases is a vast missile-launching submarine fleet in addition to their long-range bombers. It is gratifying that our own Navy is aware of this, and that underwater early warning systems and sophisticated torpedoes and anti-submarine weapons are being studied and perfected.

When only ten years ago one would dare to suggest such a thing as launching a rocket from deep under the sea, even the most respected military strategists and engineers would brush the thought off with a condescending smile. Today, as this issue of m/r indicates, highly advanced underwater missiles of all kinds are being rushed through development and test.

With the advent of truly submersible atomic submarines that can cruise at high underwater speeds for weeks on end and with the growing practical knowledge of guided missiles of all types, the oceans assume a new strategic significance.

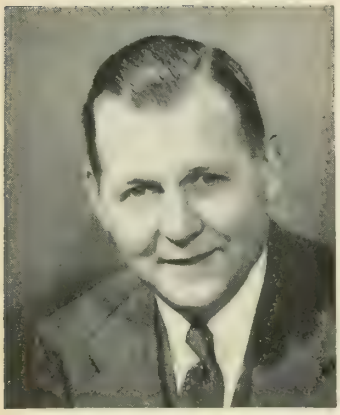
Water covers 71 per cent of the earth's surface. In places its depth exceeds 30,000 feet. It's a restless, moving thing that may stabilize the peace on earth; it is a world in hiding—one in which much of tomorrow's warfare may be conducted if major conflict arises.

One perfectly obvious aspect of the underwater missile science is the technological challenge it represents to our industry. It opens up a whole new field for designers, engineers and scientists. Our great missile manufacturers have new business opportunities, limited only by the vast defense system needed to keep our country safe against a huge fleet of deadly underwater platforms from which enemy missiles can be launched.

WAYNE W. PARRISH

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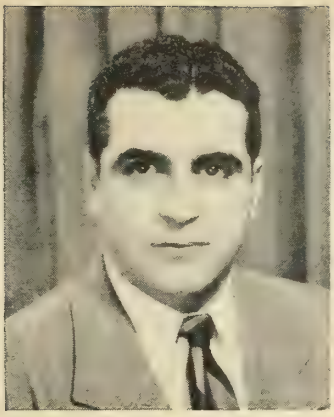


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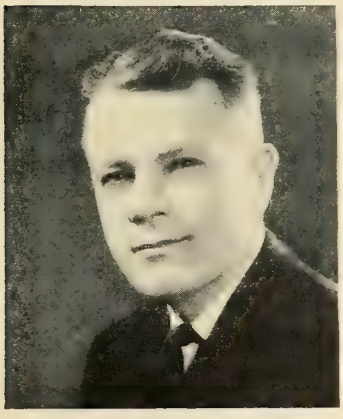
C G Holschuh



SAMUEL AGABIAN has been appointed Manager of the Air Armament Division. Formerly works manager, Mr. Agabian is an Annapolis graduate and former Marine Corps officer. His work at Sperry has included responsibility for computing gunsights, bombsights, antiaircraft devices, radar and infrared developments.

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Airborne beacons
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Airborne inertial systems



MYRON D. LOCKWOOD, manager of the Surface Armament Division, was formerly a systems engineering director. A World War II Lt. Col. of Artillery, and military-technical advisor at M.I.T., Mr. Lockwood has been associated with Sperry projects in underwater torpedo fire controls, guidance computers for missiles, antiaircraft control systems and inertial navigation equipment.

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NUCLEAR POWER AND ION PROPULSION

cover picture:



The Navy photo on the cover shows the business end of one of man's first guided missiles—the World War II torpedo. Whether sonar self-homing or guided by preset course coordinates, this beat its airborne cousins by a number of years. But, from being an undermattress for the Navy's even-tempered submarine crewmen, this missile has come a long way, as this issue of m/r so well demonstrates.

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U.S. Navy, pp. 41, 59, 60, 61, 64, 66, 71, 72, 75, 76, 77, 91, 113; Taggart, pp. 67, 68, 69; AiResearch, p. 78; E. Hull, pp. 88, 89, 159, 162; Whittaker Gyro pp. 100, 101, 104, 106; G. F. Wislicenus, p. 109; Nat'l Research Council, pp. 110, 113; Cameraman, Inc. p. 162; Robert Striar, pp. 160, 161.



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when and where

MAY

Commercial Chemical Development Assn., Spring mtg., French Lick, Indiana, May 13-14.

IRE National Conference on Aeronautical Electronics, Biltmore Hotel, Dayton, Ohio, May 13-15.

Industrial Nuclear Technology Conference, sponsored by Armour Research Foundation & Nucleonics Magazine, Museum of Science & Industry, Chicago, May 14-16.

Jet Age Airport Conference, American Society of Civil Engineers, Park-Sheraton Hotel, New York City, May 15-17.

American Institute of Industrial Engineers, 8th annual conference & convention, Hotel Statler, New York City, May 16-18.

Armed Forces Communications & Electronics Assn. Convention, Sheraton-Park Hotel, Washington, D. C., May 20-22.

ASME Design Engineering Conference, Coliseum, New York City, May 20-22.

National Telemetering Conference, Hotel Cortez, El Paso, Texas, May 27-29.

JUNE

First National Symposium on Production Techniques, sponsored by Washington Chapter of IRE, Willard Hotel, Wash., D. C., June 6-7.

First Annual National Career Conference, Sherman Hotel, Chicago, Ill., June 8-12.

Fourth International Automation Exposition and Military Automation Exposition, Coliseum, New York City, June 9-13.

ASME Semi-Annual Mtg., Sheraton-Palace, San Francisco, June 9-13.

Operations Research Conference, sponsored by Illinois Institute of Technology, IIT Campus, Chicago, Ill., June 12-14.

American Society for Testing Materials, annual mtg., Chalfonte-Haddon Hall, Atlantic City N. J., June 16-21.

National Conference on Military Electronics, sponsored by IRE PGME, Sheraton Park Hotel, Wash., D. C., June 17-18.

IAS National Summer Meeting, Biltmore Hotel, Los Angeles, Calif., June 17-20.

Aviation Distributors & Manufacturers Assn., 29th mtg., The Broadmoor, Colorado Springs, Colo., June 23-25.

Federation Aeronautique Internationale, Palermo, Sicily, June 25-30.

JULY

Air Force Assn. Convention, Washington, D. C., July 30-Aug. 4.

AUGUST

IAS Naval Aviation Mtg., U.S. Grant Hotel, San Diego, Calif., Aug. 6-10.

Western Electronic Show & Convention, Cow Palace, San Francisco, Calif., Aug. 20-23.

SEPTEMBER

ASME Fall Mtg., Hotel Statler, Hartford, Conn., Sept. 23-25.

OCTOBER

International Astronautical Federation, 8th Annual Congress, Barcelona, Spain, Oct. 7-12.



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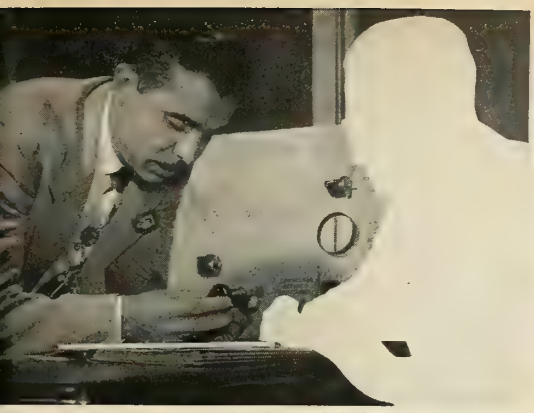
- Circuit Development
- Components
- Cost Estimating
- Digital and Analog Systems
- Electronic Packaging
- Electronics
- Field Engineering
- Heat Transfer
- Human Engineering
- Inertial Guidance
- Installation
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Creative Mechanical Engineer: Previous to his latest promotion, this engineer worked on accelerometers, inertial devices, cooling units, servo-mechanisms and new techniques of gearing for subminiature computer units which will key future development of military weapons. Associates investigated new concepts in magnetic recording and number display devices, and read-out printers. *Do you belong here?*



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mponent Engineer: This man's job entailed the selection, evaluan, development, and application of electronic component parts, or ilding blocks, used in airborne bombing and navigational systems. gineers and physicists will find stimulating opportunities here to gineer on precision analog components, gyros, accelerometers and alog-to-digital converters. *Do you belong here?*



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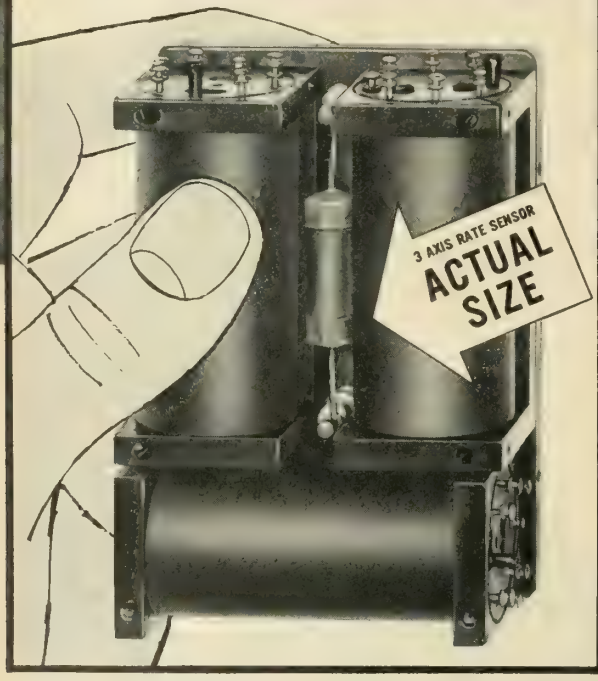
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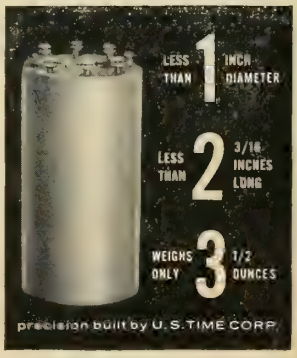
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To the Editor:

Regarding my Pentagon cleared article, "Spacepower," which you published in the April issue of MISSILES & ROCKETS, I would like to make the following comments for the benefit of you and your readers: . . . that due to my impending transfer of positions to the Martin Company from the Air Force, that any identification of my name with my present or former employer, carry a disclaimer "that my views do not reflect those of the Martin Company" or the Air Force.

Although I realize that it is an editor's prerogative to change titles and subtitles, your switch of my original subtitle: "An Analysis of Some Aspects of Space Doctrine" to "How the US Air Force Will Become the US Space Force," gave a new and different connotation to the real content of the article, which has caused me some embarrassment . . . Many readers of my article might assume that the *Vanguard* program, of which the Martin Company is the prime contractor and with which I am intimately connected, has political and military applications. The only purpose of the *Vanguard* —earth satellite program is a peaceful. scientific pursuit—to extend man's knowledge of the earth and its environs.

Donald Cox
The Martin Co.
Baltimore 3, Maryland

R-W Function Spelled Out

To the Editor:

. . . Enjoyed reading your excellent April issue; particularly the comprehensive roundup on Air Force long-range missile activities. We thought all portions were very adequately treated and were pleased to note that the role of The Ramo-Wooldridge Corp. was set forth in a very creditable and understandable fashion . . .

J. R. Lewis
Director, Public Relations
The Ramo-Wooldridge Corp.
5730 Arbor Vitae Street
Los Angeles 45, Calif.

Wants Servo Motors News

To the Editor:

Do you have a section for news items on servo motors and components?

A. B. Bradt
G-M Laboratories Inc.
4300 N. Knox Ave.
Chicago 41, Ill.

We are planning a forthcoming issue which will feature servo motors and related equipment.—Ed.

H. S. Rocket Courses?

To the Editor:

I was very interested in the letter by Leon Leonard of Seattle in the March issue, since I am associated with what is apparently a group similar to the one he describes. In my case the name is the Wakefield Rocket Society of Wakefield High School, Arlington, Virginia.

I very heartily agree with Mr. Leonard that high school student interest in Rocketry is being neglected and that this is a crucial phase of missile education. An account of our Society and its activities may give your readers an idea of what is being done and what can be done with this age group.

About three years ago George Pickard, a tenth grade student in the Arlington schools, decided to implement his growing interest in Rocketry. He gathered the nucleus of what eventually became the Wakefield Rocket Society . . . now in its second year.

Little was accomplished the first year, but this year's accomplishments were



interesting. Upon application, the group was accepted as an official Moonwatch team; work is now in progress on the construction of the observing station.

In cooperation with the University of Maryland, the group is building a cosmic ray recording station. Several visits have been made to local scentific installations; weekly meetings are "operation bootstrap" in missile education. Six of



the group ushered at the recent ARS convention. I must mention also that difficulties associated with actual launchings have led to the construction of a static test stand, and a program of experimentation with powder and liquid propellants is under way.

This is a good record of accomplishment and were such clubs not so important I would not go on to complain. Yet I feel I must, and my complaint is directed toward that same indifference Mr. Leonard mentions.

I was surprised to read that Mr. Leonard has received assistance from the Northwest Section of the ARS; the parent organization does not appear to have the perception of its Northwest branch. Our efforts to become associated in some way with the ARS have come to nothing.

Reason given is that the Society is afraid of incurring liability in case of accident. I cannot help but feel that this attitude is a tragic mistake; these boys are the scientists of tomorrow.

We must remember that our educational system depends upon people choosing their careers and not being ordered into them. The ARS should have an active program designed to interest capable students now in secondary school.

Other than Reed Research Inc. in Washington, D.C. we have had little success in attracting the attention or interest of industrial research organizations. At one time, Atlantic Research gave some evidences of interest but nothing has developed.

Several individuals have been very kind, but what we need is room for firing, equipment, and the advice of people more technically competent in this field than I.

In closing, I should like to predict that the number of rocket societies will grow in the next few years. The publicity given missile work makes growth inevitable. I hope this letter stimulates some group to step in and assume some of the responsibility practicing scientists owe to these student groups.

David W. Saltus
5433 Eighth Rd. S.
Arlington, Va.

Watch Your Language!

To the Editor:

Re your answer to Albert Parry in Letters April 1957—All I can say is:

Жиперс, Ватта Дерти Трык!

Also—where does the Lintz Basalt occur?

Kelly Choda
732 Ursula Street
Aurora 8, Colorado

It's a volcanic deposit. Lintz Basalt, in particular, comes from Germany.—Ed.

But Has It Been Cleared?

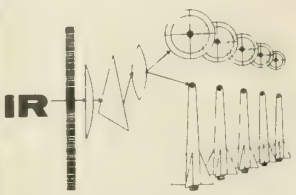
To the Editor:

Recently in cleaning out my desk, I came across the following, which may be of interest to your readers:

PROJECT VOGELHUNDT

"Firing of rockets, bombs, missiles, and projectiles in tests at NOTS are accomplished in tests of one kind or another. The conducting of a survey prior to the current reports period (1956) indicates that out of approximately more than 200,000 total rounds fired altogether per year and valued at some million and a quarter dollars, it is desirable for study purposes to recover about 20,000 having a total approximate value of about half a million dollars in all. However, further accumulation of data statisticswise showed that of these 20,000, only 10% were usually

INFRA-RED IS ULTRA-MODERN



In the post-war years, the development of infra-red devices has attained the dimensions of a technological breakthrough. In this period, the Electronics and Guidance Division of Aerojet-General Corp. has become the national leader in the development and manufacture of infra-red equipment.



Aerojet offers qualified engineers and scientists unparalleled opportunities in every area of the guidance and propulsion field.

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letters

recovered and 90% had a strong recover incapability.

"Optical, auditory, and shock-sensitive devices developed this year have proved of but slight value either costwise or information-contentwise. Some detection methods are valued on the order of 20 times the material recovered.

"In 1956, however, it was noted that olfactory processes, at least in organic fields, are among the most sensitive of sensing devices. If the cost dollarswise of the search-and recovery processes could be reduced to a cost calculated centwise, by using scent-sensitive sensing equipment, it appeared sensible to develop and prove the technique which seemed sensational.

"Mechanical sensors were found impractical, but a careful study of current literature revealed that many varieties of organic sensors are available in large quantities and at low cost.

"After intensive study, it was found that one highly specialized organic sensor, the Bassett Male Aero Bark X3A was suitable as an olfactory detection unit, but that this unit would not operate without a corresponding sensitizing unit to sensitize the weapons before firing.

"Organic sensitizers need not be restricted to the Aero X3A; so several varieties were obtained, including Mastiff Female Yipe 6 and Setter Female Yipe 8. All apparently had equal sensitizing capability and were used in turn to sensitize missiles to be fired at the Randsburg Wash Range.

"Test projectiles were fired in groups of 40 because it was found that the Bassett Aero X3A became insensed after a period and had to be recharged.

"On three tests, in which 120 missiles were fired, the Aero X3A was stationed in a shelter near the anticipated target area. One hundred nineteen of these landed in the target area and were located by the Aero X3A in rapid succession. The average time for search and detection was 0.71 minutes. However, projectile No. 73 accidentally was fired at high gun elevation, and the projectile landed in the foothills of the Panamint Range. Operations had to be suspended because the Aero X3A left the field of operations at approximately more than 121.3 fps, and it was approximately one hour before the Helicopter Recovery Group was able to effect the capture of this sensing unit and return it to the operations area.

"It is the consensus that if some more effective means for stimulating the unspecialized sensitizing units can be devised, olfactory detection will provide an effective and economical means of recovering valuable test weapons after firing. Censing the projectiles before firing, the sensor could be more effective. It is also anticipated that the use of more than one Bassett Male Bark Aero X3A will considerably reduce the wear and tear on these units. It is also believed that the addition of one or more Bassett Female Yipe Aero X3A's will assure a constant supply of these valuable units."

John H. Wilson
Atlantic Research Corp.
Alexandria, Va.

Plaudits for Us

To the Editor:

I had the pleasure this week of being given a copy of your new magazine, MISSILES & ROCKETS. A colonel who was attending our course of familiarization on Electronic Countermeasures thought that it might be a valuable source of information for our guided missiles lecture. We have really found this to be so.

We present this course every week to high ranking officers of all services, including the Royal Air Force and the Canadian Air Force . . .

R. Kevin Murray
Captain, USAF
OMR Box 69
Keesler AFB, Miss.

Fashions in the Sky?

To the Editor:

At the suggestion of the New York office of *American Aviation* Magazine, I am writing you to see if you can give me an approximate date for the launching of the New Earth Satellite. We understand that this will take place sometime during the summer.

It may seem strange for a retail store to be interested in such a highly scientific project, but we feel that it might be interesting to tie in some of our ad copy with the launching of the satellite.

Alison M. Beyea, Fashions
New York Office
Neiman-Marcus
1457 Broadway
New York 18, N. Y.

No date has been set yet. It depends on when the launching vehicle is in satisfactory condition. This may not be until the middle of 1958.—Ed.

Wants Red Missile Sources

To the Editor:

Your map on pages 40 and 41 of the February m/r, depicting the Soviet missile industry was very interesting. However, in the European Russia region the map was pictorial but confusing. Association of some symbols on the map with the nearest locality indicated conflict with information we already have on hand, some symbols were simply impossible to locate satisfactorily, etc.

Could you possibly furnish me with some of the specific information that was on hand when the map was drawn up, or indicate the sources and channels thru which the information was obtained?

It is thru the particular responsibilities and interests attached to my work as a Research Engineer in Missile Development Division of North American Aviation that I am interested in such information.

J. D. Harmon
11351 W. Olympic Blvd.
Los Angeles 64, Calif.

We cannot give our sources beyond saying that they consist of Governmental and private sources both in the U.S. and abroad.—Ed.

Emancipation Revisited

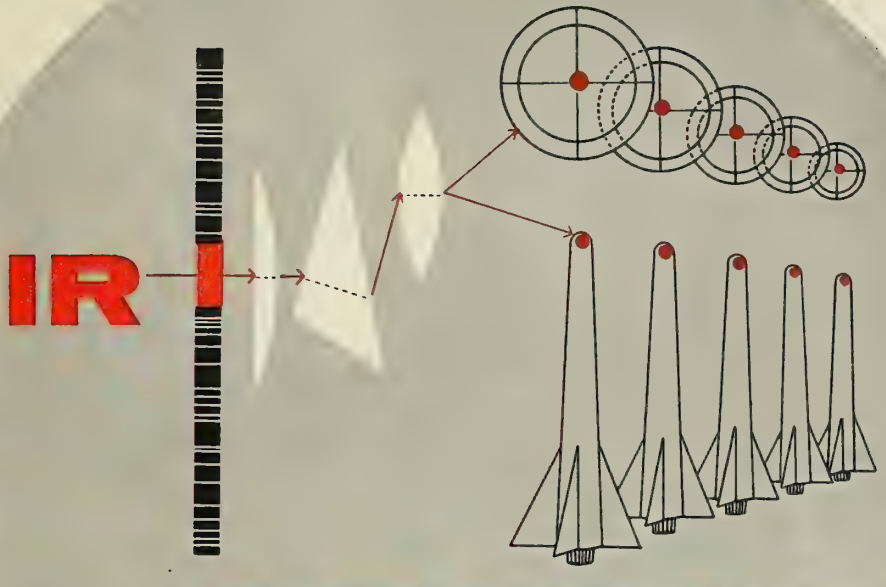
To the Editor:

This has been getting chuckles in Florida and San Diego.

I thought you might appreciate—

"GETUSABIRD ADDRESS"

"Four months and some weeks ago, our company brought forth to this base a new missile, conceived in haste and



INFRA-RED

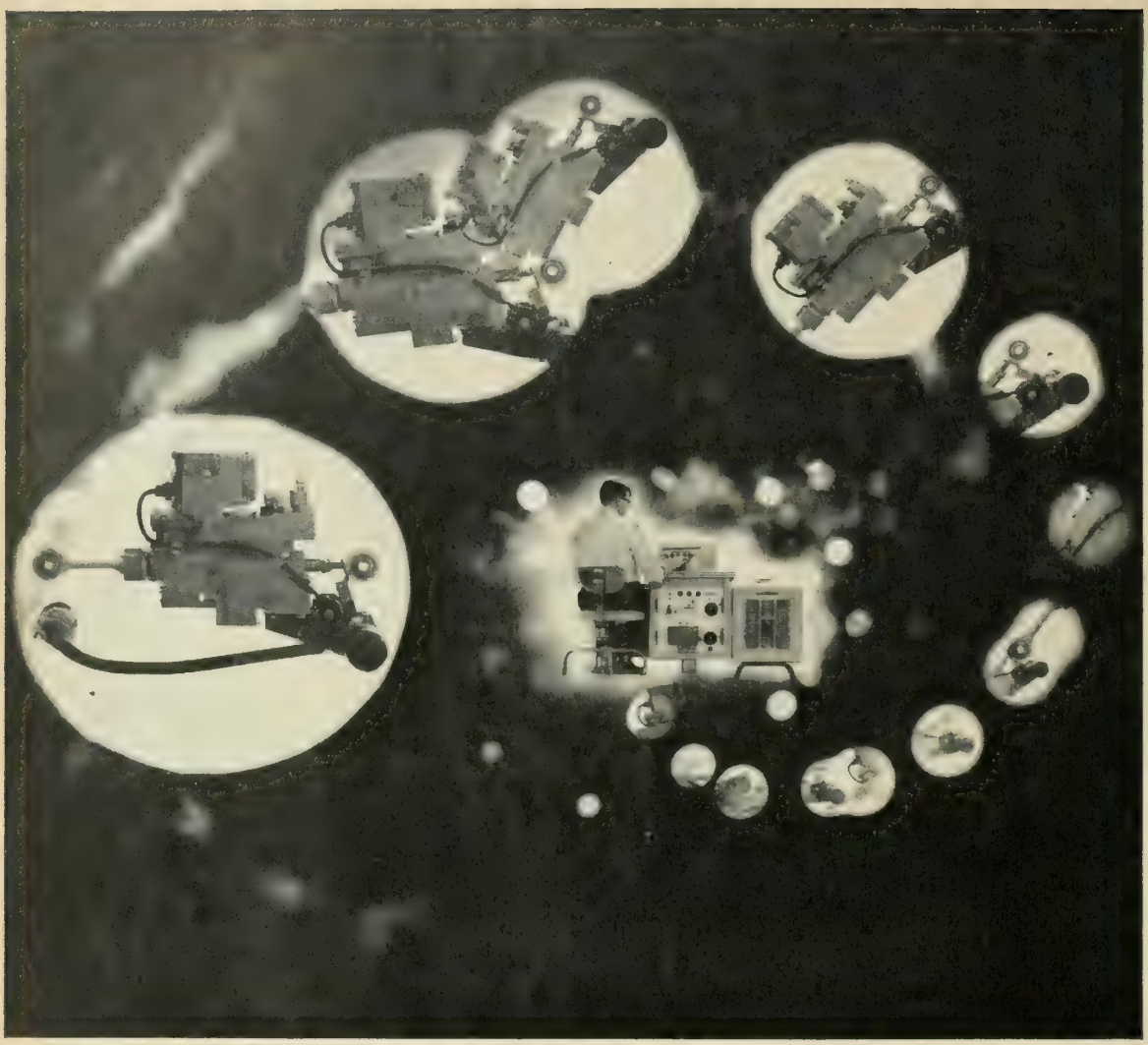
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Standardized "postage-stamp" circuits allow engineers to mockup even highly advanced designs almost as simply as they would plug in an electric shaver. And AUTONETICS' data processing equipment can simulate a wide range of operational missions, as well as solve the most involved mathematical problems in minutes instead of days.

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dedicated to the proposition that all components are created equal.

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"We are met on a great flight path of that program. We have dedicated a portion of that flight path for a final resting place for those missiles that here went down range, that this base might continue to exist.

"It is altogether fitting and proper that we can do this. But in a larger sense, we must test; we cannot rest; we must justify this program.

"The brave men, officers and contractors who have built their empires here, have justified it far above our poor power to add or detract.

"The people will little note, nor long remember what we say here, but they can never forget what we did here. It is for us, in Florida, rather to be dedicated here to the unfinished task which they, at San Diego, have thus thrust upon us.

"It is better for us to be here completing the diminishing tasks remaining before us: that from the public we take increased taxes for this cause for which they gave the last full measure of approval; that we here highly resolve that these taxpayers shall not have paid in vain; that this base, under ARDC, shall have a new birth of accomplishments: and that missiles of the contractor, by the contractor, and for the contractor shall be launched from this base."

W. G. Bennett
Convair-Astronautics
San Diego, Calif.

French Isopropylnitrate

To the Editor:

I note in Al Zaehringer's column "Propulsion Notes" in March m/r a reference to a method for producing isopropylnitrate, which has been devised by the French.

I would appreciate receiving any further information whatsoever you may have on this subject.

May I take this opportunity to say we find your journal extremely interesting and valuable in connection with our interest in monopropellants and fuel additives.

Harold A. Beatty
Technical Staff
Ethyl Corp.
Detroit, Mich.

It is in the mail.—Ed.

Russian Carbon?

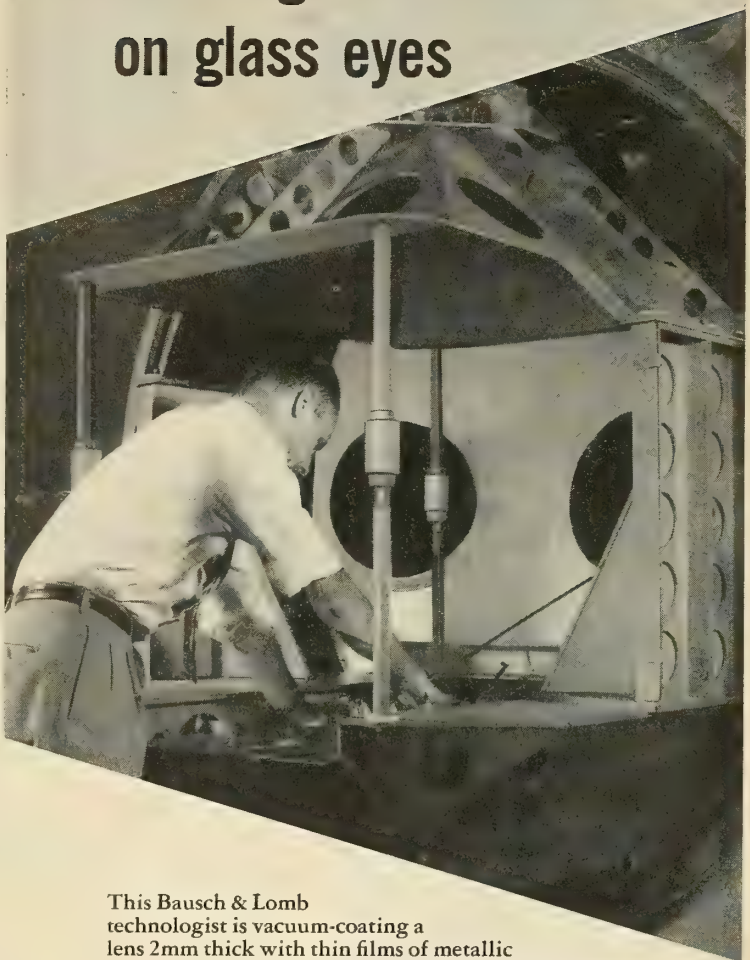
To the Editor:

I have just seen another Russian drawing on the earth satellite project.

It looks as if Mr. Dobrovolsky didn't make such an obvious copy of the Mouse as was done in the drawing that you reproduced last November. I don't know whether this latest Soviet satellite conception is the result of copying some other American design or represents some original Russian thinking on the subject.

Incidentally, this February, 1957, issue of Nauka i Zhizn also carries a five-page article by Varvarov titled "Artificial Earth Satellite." Included is a black-and-white drawing of a three-stage satellite launching rocket and sections on "Theoretical Premises", "Satellite Projects", "Methods of Launching the Satellite", "The Avanguard (Vanguard?) Project",

Grafting metal skin on glass eyes

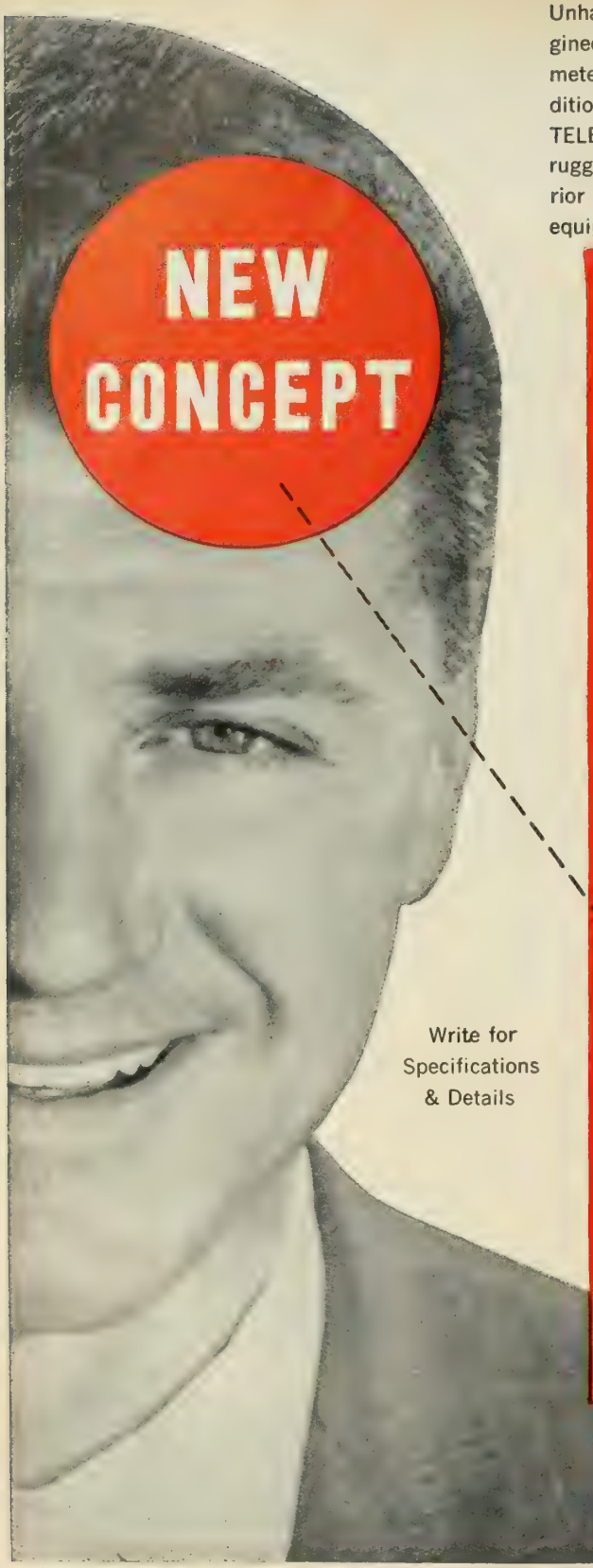


This Bausch & Lomb technologist is vacuum-coating a lens 2mm thick with thin films of metallic salts to increase control of light and color. If the lens were enlarged to the height of Mt. Washington (6,288'), the lens coating would be equivalent to a four-inch transparent layer. This submicroscopic surfacing method, developed by B&L, makes possible miracles in selective reflectance and transmittance of light of any specified wavelengths. Practical applications range from color TV to directional control of guided missiles. How does this kind of advance technology fit in with your contract plans?

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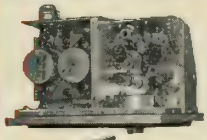
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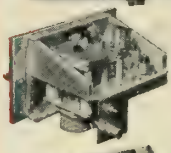
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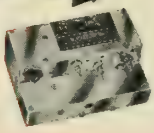
Direct FM Transmitters Crystal controlled 215-235 megacycles. 125kc deviation.



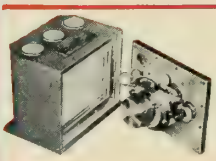
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x 2.7"
2 Watts

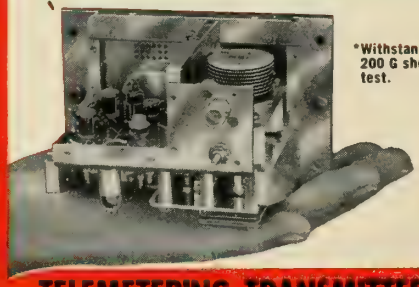


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letters

"Use of Various Engines", "Will the Satellite Be Visible"? and "What Will the Satellite Do for Science"?

In an earlier issue of Nauka i Zhizn, V. V. Rozenblat, a Russian candidate of medical sciences, wrote a four-page article on the psychological problems of space flight. In all probability the problems discussed are pretty much the same as those you have written about: acceleration, strain, weightlessness, feeding the crew of a space ship, etc.

Chuck L. Adams
3330 Thirteenth St.
Boulder, Colo.

Is Gravity Constant?

To the Editor:

I would like to know your reference for the statement in "Missile Miscellany," of the March m/r, which says that "a gravity pendulum with a bismuth bob gains one beat in 17.432 by another pendulum of exactly the same oscillation length having a zinc bob." I would also like to know if the figure, 17.432, should not be 17,432. This sounds a little more reasonable.

Congratulations on a fine publication.

Richard E. Brown
41113 Menlo Dr.
Wichita 17, Kansas

The figure 17.432 as printed is correct, which means that the shift in period is quite rapid—Ed.

To the Editor:

In the February m/r "Missile Miscellany" section you state: "Has any one ever used modern theory to explain why the silicate, Lintz basalt, spontaneously generates heat at the rate of 2.38 x 10-4 calories per hour per gram; why *in free fall it won't accelerate at 980 centimeters per second?* It's not radioactivity, for uranium is 1500 times as active as Lintz basalt, generates only 7.2 x 10-5 cal/hr/gr."

In an attempt to get an explanation, this paragraph was shown to two physicists. Their reaction was to dispose of the problem by exclaiming, "Hogwash!". I am not inclined to dismiss this alleged phenomenon so lightly, but must admit that I am more than a little doubtful of the validity of the assertion regarding the acceleration of Lintz basalt in free fall.

I would, therefore, appreciate more detailed information on the subject, if at all possible. Also, I would very much like to know the source of your information.

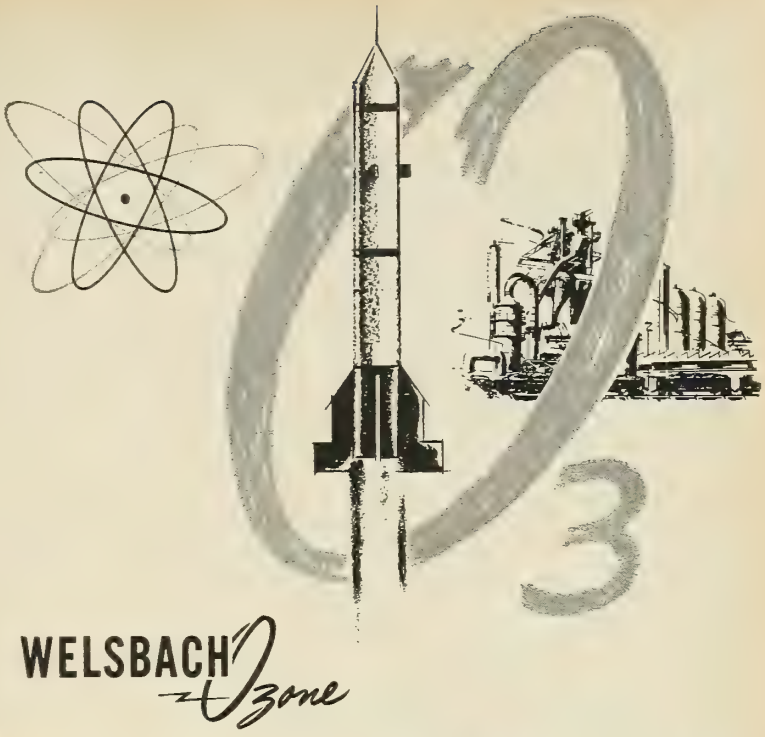
C. C. Barnett
General Electric Co.
Missiles & Ordnance Systems Dept.
Philadelphia 4, Pa.

Our experience is that those who claim "hogwash" merely assume it, have never checked it. A letter is in the mail giving you complete references—Ed.

To the Editor:

It's interesting to see that you're stirring up the relativity time-contraction controversy sparked off over here by a letter from Prof. Dingle in "Nature," and continued both there and in "Discovery" by most of our "big guns" in relativity theory.

Lead v. bismuth pendulums—I sup-



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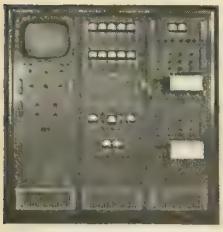


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pose someone has investigated the possibility of eddy-current damping from the Earth's magnetic field? If this, and the Lintz basalt phenomenon tie up together, we might get a real anti-gravity unit.

Astropsionics?

I'd like to comment on certain aspects of some of the serious articles, but I'm a bit scared of security—there have been instances of people being refused permission to use material in public lectures here in spite of it actually being published; that recent leak of "Sea Slug" also had security types going round in small circles, tho' what actually got out couldn't be of the least value to the Queen's enemies, as far as I can see. Still, I suppose that it's a question of principle.

P. H. Mabey
201 Bath Road
Cheltenham,
Glouc., England

To the Editor:

. . . I have come across an article in your magazine which has stirred much interest. The article appeared in m/r, March 1957, page 113:

"Relatively also requires the equivalence of gravitic and inertial mass. If so, explain why a gravity pendulum with a bismuth bob gains one beat in 17,432 by another pendulum of exactly the same oscillation length having a zinc bob; and why torsion pendulums act similarly."

Can you please supply me with the source of your information?

Who made this discovery? If this is true, isn't g dependent on mass? . . .

Alfred F. Kudela
Senior Engineer,
Chrysler Corporation
P.O. Box 2628
Detroit 31, Mich.

This phenomenon may have some bearing on the theoretical g-mass relationship. More likely it has to do with diamagnetism. In any case it appears to be a phenomenon that's been looked into only a little. The reference is Journal of the American Physical Society, Volume XVIII, No. 2, page 125, a paper presented by Charles F. Brush.—Ed.

On Vanguard Switching

To the Editor:

I am very interested in astronautics and m/r is the fulfillment of my dreams in the field.

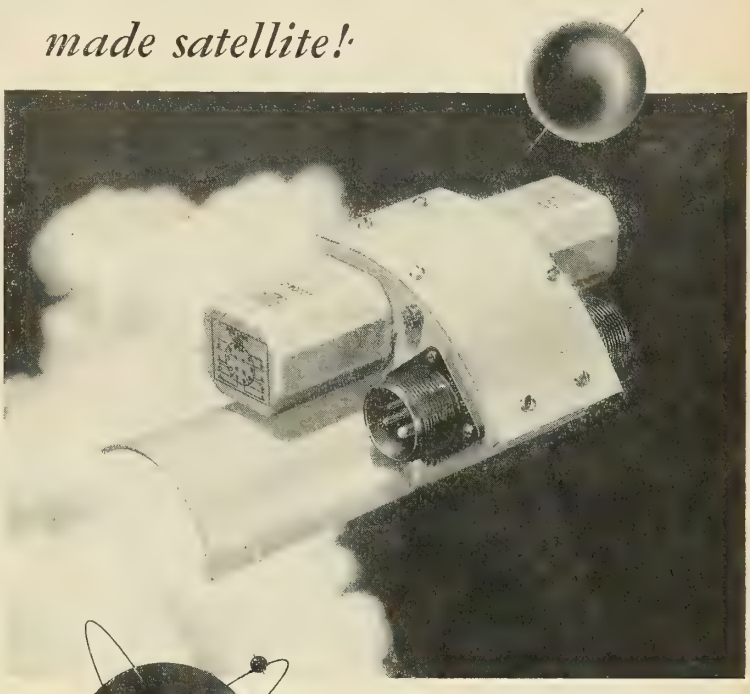
In an article about the *Vanguard* Project, I saw that there was a sun-cell to reset a memory unit in the satellite once every circuit. What happens if the satellite is rotating on its axis more than once per circuit? Looks like the memory unit would erase information already stored, but not yet transmitted, and a great amount of information would be lost. Do you have any information on how this is being remedied, or is it?

Also where could I get an index for m/r and pictures of rockets, missiles, and planes.

Drew Evans
207 Taft Ave.
Wilmington 5, Del.

Vanguard's switches are programmed to act relative to its orbiting cycle. An m/r index will be published this fall. For pictures we suggest you try the public relations offices of companies involved—Ed.

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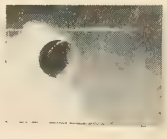
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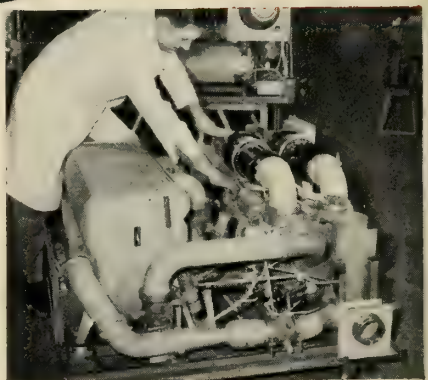
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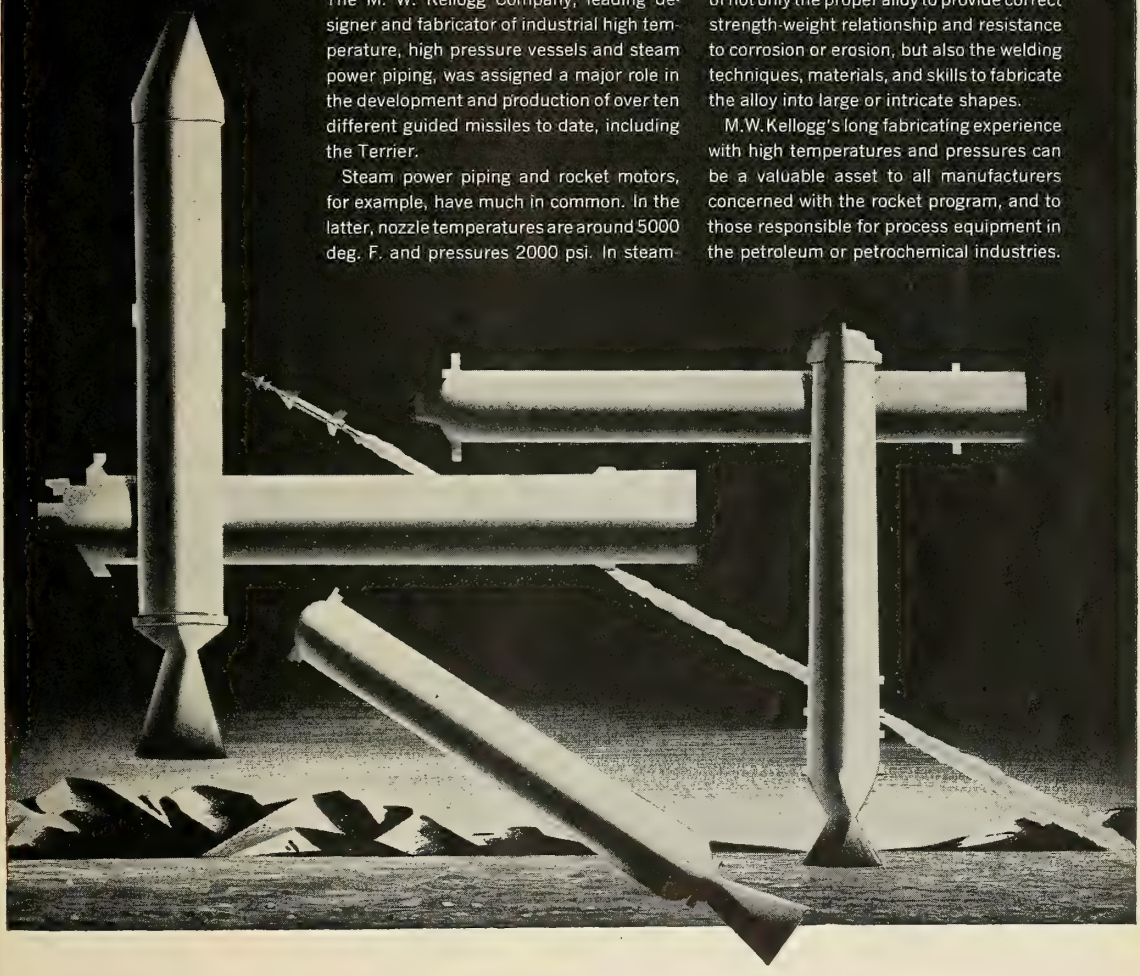
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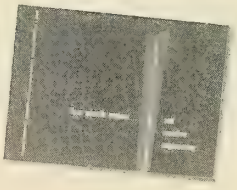
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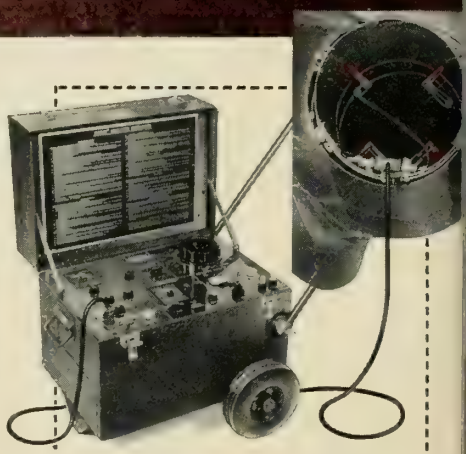
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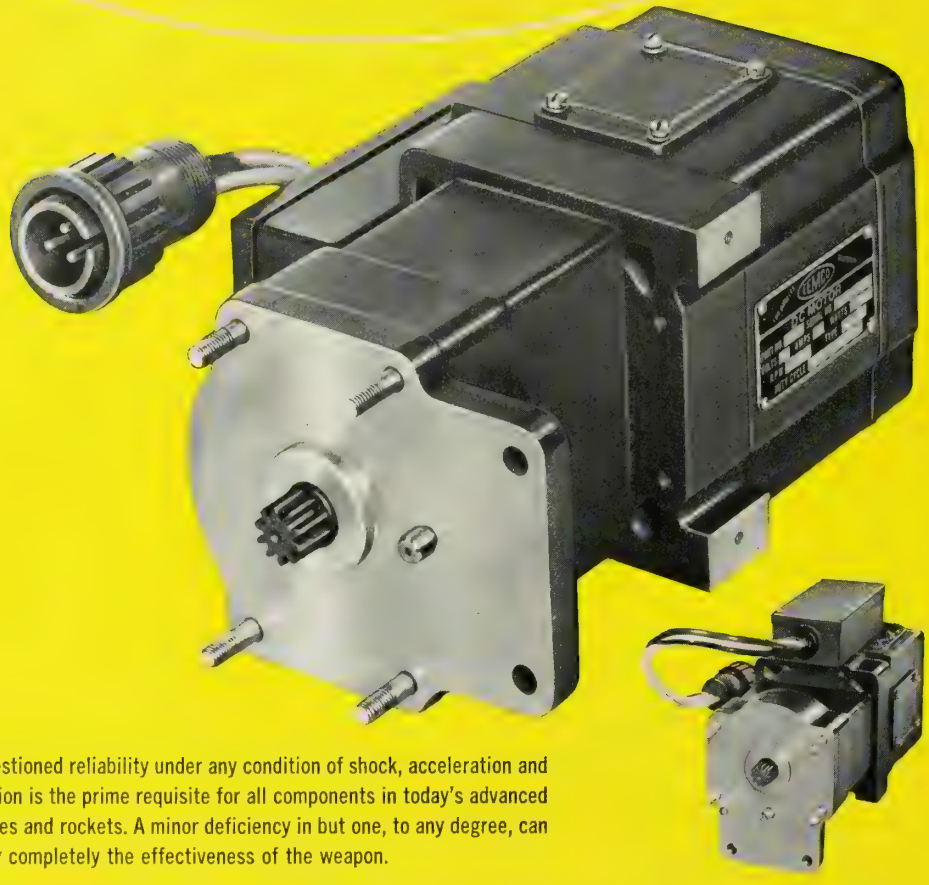
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Chain of Low Frequency Sonar Devices Will Detect Enemy Subs

By Erik Bergaust

The United States Navy is understood to be conducting a program for what may turn out to be the most sophisticated defense weapons concept ever attempted. We are building an underwater early warning system similar in scope to the famous radar detection systems stretching across northern Canada. But the USAW (Underwater Security Advance Warning) concept is based upon highly advanced underwater sonar devices linked together in long chains at the ocean floor up and down our coasts. The system is designed to detect enemy submarines that may sneak up toward our shores. This system—as part of an anti-submarine system—is believed to be our most potent answer to Russia's vast submarine fleet, many units of which are designed to carry the 700 miles range *COMET* FBM or IRBM missile. Employing the submarine launching concept the Reds would be capable of hitting targets along our coasts as well as inland from launching positions less than 100 miles out at sea.

The underwater early warning system is top secret. No details whatsoever can be released, although it is understood that certain companies, such as American Cable & Radio, have submitted proposals and might have been awarded contracts at this time.

Our undersea warfare people are working under tighter security wrap than any other branch of the services. Little has been said about their many different weapons systems and their research and development, but a high-ranking Navy official has confirmed to m/r that work is progressing on the underwater early warning system. Said one Navy captain, when asked how many subs we could detect if Russia sent 500 of them toward our coasts: "Today we probably could only detect 10 per cent of them."

The future system will be much like a chain of Texas towers deep down in the sea. Chains of sonar buoys, operating on a passive basis, i.e. *listening* for enemy submarine noise, would be linked together. At certain intervals computors will calibrate the sound wave information and transmit it to a central defense headquarters, much like the SAGE system.

Underwater experts agree the underwater warning system can be made effective, since advancement in the field of low-frequency sonar has been substantial, and since it his been proven that ships can be detected by passive sonar as far off as 100 miles, perhaps even farther.

During the war sonar was developed to the extent that a convoy could be heard with ease at 40 miles distance. A large ship could be detected 70 to 80 miles away, and an underwater explosion could be heard more than 100 miles away.

Many of the major electronics companies in this country are working on advanced sonar devices for torpedoes and other underwater warfare purposes. And the interest in this science is growing.

Navy's need for improved sonar devices—for underwater early warning along our coasts and for shipborne



Artist's conception of underwater early warning system. Enemy subs (A) will be detected up to 100 miles away by passive sonar buoys (B) that are linked together with computer system (C) and controlled from SAGE type headquarters (D). It will also measure sea conditions.

sonar—is expected to influence the electronics industry noticeably in the next few years. Some experts have even considered the possibility of hooking up an underwater early warning system to automatically controlled detonation devices and self-launching missiles. This may belong to the distant future. But the immediate application of sonar as a straight detection system is imminent and feasible as well.

Engineers For Sonar Industry

Recently Cal-Tronics Corporation of Los Angeles awarded a scholarship to a high-school student for his sonar electronic exhibit, displayed at the Annual Science Fair at the Los Angeles County Museum.

The winner was judged by Cal-Tronics executives including Malik Robinson, vice president; Ralph Koerner, manager of engineering; Stanley Boyle, development engineer, and Robert Feland, Jr., sales manager of the firm which specializes in testing equipment for guided missiles, radar and fire control.

The scholarship was awarded to stimulate recruitment of engineers for the growing electronics and sonar industries.

Unique Sub Detection System

A recent AP dispatch from Sweden disclosed that the Swedes have been considering the use of seals to hunt down submarines.

"Yes, we tried it," a naval spokesman told, "and you needn't get flip about it. The seals cooperated but we couldn't handle the fish."

Seals were put in training during World War II at a Swedish naval base, where submarines were sent down with bundles of fresh herring attached. The seals went for the herring joyfully.

There were two snags in the project, as the Swedes saw it, which had to be overcome to make it workable.

One was to supply the seals with "war heads." Since a seal's body is pretty streamlined and slippery, a top secret order went out to the Royal Institute of Animal Medicine to devise a suitable plastic operation to take care of this difficulty. This idea was discarded in favor of an "explosive harness" of special design.

The project foundered on the second snag. Despite intense training, the seals looked with perfect distain upon any submarine without the herring bait.

60-Knot Missile Subs Planned

A major technological breakthrough in underwater warfare is under way. It consists basically of the development of an engineering ability to break the "cavitation" barrier, that hydrodynamic phenomenon that now proves as troublesome to underwater missile and submarine designers as the sound barrier was to aerodynamicists a scant dozen years ago.

Vice Admiral Charles B. Momsen, USN (Ret.) in m/r's *personal report* (page 88, this issue) states categorically that 60-knot submarines are bound to come. It is not idle speculation.

He is a central figure in the work towards high-speed underwater capabilities. Now a consultant for such firms as Electric Boat Division of General Dynamics Corp., Coleman Engineering Corp., Fairchild Aircraft and Engine Corp., Raytheon Manufacturing Corp. and U.S. Rubber Co., Adm. Momsen probably knows more of the limitations and potentials of undersea warfare than anyone else alive.

A number of privately financed research and development projects, taken collectively, add up to just such a vehicle. The most important single contribution to the 60-knot (and up) submarine will be designed for the elimination of cavitation—a low-pressure turbulent flow condition where gas bubbles form between the fluid medium and the skin of the vehicle. Elimination of cavitation plus the development of highly-polished underwater surfaces might cut high-speed drag 70 per cent.

Details of specifically who is working on the 60-knot submarine and in what capacity are classified, both for military security and for proprietary reasons. But an official announcement that the Navy is building such a vessel may come this year.

However, there are indications of what form it will take. First, it will probably be small and will be the most fully automated subsea craft ever launched. Its crew will probably consist of fewer than a dozen men. In that respect it will approach the airborne bomber in basic operational concept. Already, the revolutionary *Albacore* is "flown" with yoke, seat belts, etc. It performs a perfect needle-ball chandelle on rudder controls alone, obtaining the stability effect of dihedral by placing the center of buoyancy well above the center of gravity.

The 60-knot submarine will be nuclear propelled. Most importantly it will utilize a revolutionary system of hydrodynamic boundary layer control in order to maintain laminar flow throughout all speed ranges. It will have passive sonar gear with effective ranges reckoned in hundreds of miles.

It will be armed with reaction-propelled missiles with underwater speeds of 150-200 knots for anti-submarine (or surface ship) missions; with underwater-to-air anti-aircraft missiles; or, of course, the Fleet Ballistic Missile.

Increasingly, it will be necessary to design submarines for their special missions. Anti-submarine submarines will be like today's supersonic interceptor aircraft. Instead of carrying radar gear to detect and track their targets, they will be literally built around the finest sound detection gear possible. They will sit and listen in absolute silence for either the noise of an attacking submarine or a "bogey" report from USAW (Underwater Security Advanced Warning—Page 37, this issue). At this moment, the anti-sub submarine will either launch its missiles while at rest or streak off after its target, depending on the distance at which the detection was made.

The strategic missile launching submarine, cradling a *Polaris* nest will have an assault capacity on the entire land mass of Russia. Lockheed Aircraft Corp., though admitting that early FBM's will have only a 1,500 mile range, has strongly hinted that 2,000-mile missiles will follow shortly thereafter. This will be the big bomber of the submarine fleet, loaded to the gills with underwater navigational and computing gear and boasting at least two nuclear reactor engines for both speed and endurance. It will not be dissimilar in size and propulsion to the *USS Triton*, a twin reactor-powered radar picket submarine now abuilding at Electric Boat's Newport, R. I., yards.

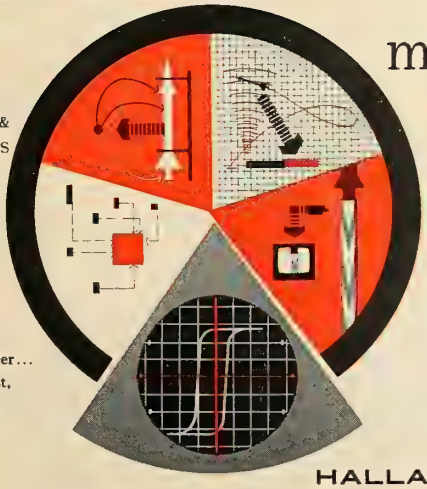
Other submarine configurations will include anti-aircraft vessels that range the seas, ready to fire either beam rider or self-homing missiles from underwater at attacking aircraft or missiles; a privateer-like vessel possessing extremely high speeds, a variety of armament and with a mission to seek targets of opportunity of all sorts; personnel transporters; possibly aircraft carriers; and cargo vessels.

In the later regard, U.S., British and Swedish work on towed underwater bulk cargo barges is significant.

The breakthrough to 60 knots for submarines will be just a beginning. Aerojet-General Corp. is working on advanced underwater propulsion for missiles. This knowhow would be applicable to submarines.



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missile outbound

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On-again, Off-again Missile Now On Schedule?

The now-it-will, now-it-won't missile, now, for the moment, will. The $39-million *Vanguard* now seems closer to being on schedule than it has in many months. In fact, with the recent successful firing of *Viking-14* with what is believed to be Grand Central Rocket Co.'s third stage *Vanguard* engine, the project may even be ahead of schedule.

The biggest question mark about when the U.S. would make its first "for keeps" effort to launch an artificial earth satellite has revolved recently around whether or not General Electric Co.'s first-stage engine would be successful. Early last month the press carried stories about how this phase of the project had been declared a failure, that Naval Research Laboratory might turn the Army Ballistic Missile Agency at Huntsville, Ala., for a first stage. The first three engines delivered by GE were, in fact, rejected as unsatisfactory. Now within a couple of weeks, this whole view has been reversed. The official word is that General Electric has solved its first-stage problems (reportedly, overheating) and that the engine is in the process of being accepted.

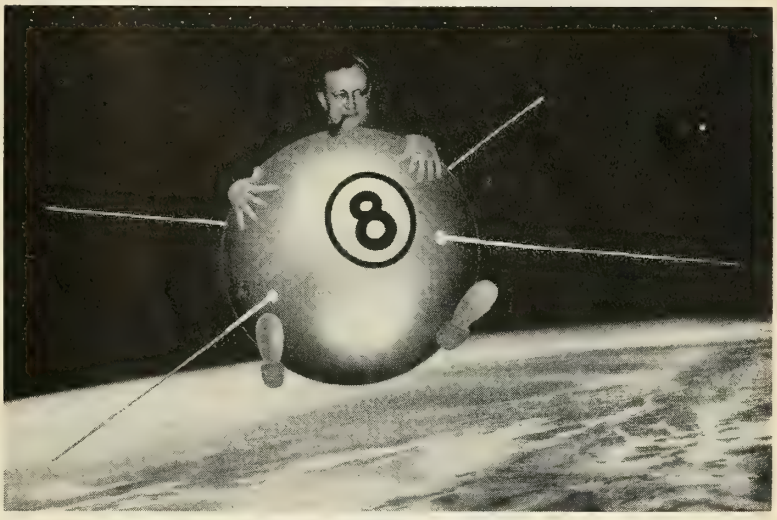
This series of events highlights the confusion surrounding Project *Vanguard*. Another contributing factor probably is the number of different agencies and groups having a hand in its direction. Also, as someone recently declared, "*Vanguard* is politically sensitive." This is particularly true where U.S. international prestige is concerned.

Other *Vanguard* developments include: completion of the purchase land for minitrack and visual tracking stations both here and abroad; beginning of construction and installation of gear at these locations; virtual completion in Washington, D.C., of the International Business Machines computer that will collect, colate and analyze reports from these and other stations.

A quick spot-check of the various major contractors in *Vanguard* propulsion indicates that the GE first stage is now all right; so, it is claimed, is Aerojet-General's second stage. Both of these are liquid rockets. Of the two third-stage competitors, Grand Central is reported to be completely out of any woods it might have been in—so confident in fact that some company officials have claimed that if the second stage liquid engine didn't pan out, they'd deliver a solid-propellant engine for that job in six months. Allegany Ballistics Laboratory, the other third-stage company, earlier was having trouble with burnouts in the engine's plastic casing, but it was confident of an early solution.

The Martin Co., *Vanguard* systems contractor, is now so confident of success of the project that it has recently hired a special man to handle all *Vanguard* publicity and enquiries. He is Dr. Donald Cox.

Meanwhile, with the last *Viking* having been fired, future launchings in the test series will probably be made exclusively with *Vanguard* components. Though all engines have been statistically tested many times, only one third stage has actually been launched. The tentative schedule now is to fire the GE first stage alone; GE first stage plus Aerojet second; then GE first, Aerojet second plus ABL third.



Aware of the telephoned, mailed and personal plaguing that Dr. John P. Hagen, Naval Research Laboratory Head of Project VANGUARD gets from quarrelsome cranks, well-meaning experts and the idly curious, an NRL photographer montaged Dr. Hagen behind the Vanguard eight-ball, a reasonable facsimile of which m/r reproduces here. Dr. Hagen's comment on seeing it was: "We can't have this kind of erroneous material leaking out of NRL. I have four feet—two of them for dragging when I'm asked to do something I don't want to do."

85TH CONGRESS
1ST SESSION

H. R. 2873

IN THE HOUSE OF REPRESENTATIVES

JANUARY 14, 1957

Mr. KARSTEN introduced the following bill; which was referred to the Committee on Foreign Affairs

A BILL

Officially designating the first earth satellite.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Earth Satellite Number One be officially designated as the "Astranaut".

For the second straight year this bill, introduced by Rep. F. M. Karsten (D.-Mo.), is shelved in the House Foreign Affairs Committee. Karsten, wondering if the committee feels it doesn't have jurisdiction, has introduced a resolution to set up an Extraterrestrial Exploration Committee. Meanwhile, Astronant is no closer to being a name for VANGUARD'S pay load.



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Underground Missile Plant to be Built Near Redstone

HUNTSVILLE, Ala.—The White House-State Department decision to supply the members of the North Atlantic Treaty Organization in Europe with missiles for mutual defense has resulted in an acceleration of activity at Redstone Arsenal, Army Ballistic Missile Agency and the Ordnance Guided Missile School. Employment at the three agencies has risen from 12,000 in December to 14,000 as of now.

And in the wake of the NATO decision several of the companies which have begun operations here in the past few years to work with the missile and rocket development teams at Redstone and ABMA, have been increasing their local personnel and planning for an expansion of activity that seems to be leading them more and more toward the manufacture of larger quantities of components and parts and even complete missiles. These include Chrysler, Thiokol, Aerojet-General and U.S. Industrial Chemicals division of National Distillers.

There has also been increased activity on the part of American Machine & Foundry which holds the rights to excavate nearby Green Mountain for what is commonly supposed to be the first U.S. underground factory for the manufacture of missiles and rockets, coupled with a sort of subterranean "junior Pentagon" where elaborate headquarters would be installed to direct the defense of the southern U.S. against enemy attack.

Several citizens of Huntsville have obtained permission from the State Docks Commission to purchase from the Tennessee Valley Authority some 200 acres of land on the Tennessee River for the purpose of building new docks that would serve the AMF underground factory. The money has been raised for the purchase and final consummation awaits only the completion of legal formalities.

Simultaneously, a new company, known as Chemstone would construct a limestone processing plant to crush the rock excavated from Green Mountain, converted into cement and other products and ship it out via the new docks. Involved in all this activity is a payroll of some 5,200 persons—or at least a 10% boost in the population of Huntsville, which has grown from 16,000 persons in 1950 to 52,000 today.

Another reassuring development has come in the refusal of the team led by Dr. Vernher von Braun to forsake their duties at Redstone and ABMA for many luring offers made by private industry located elsewhere. Despite all the hullabaloo since the Wilson decision of last November and the known presence here of "talent scouts" from a dozen or more large firms deeply interested in missiles and rockets, only one minor defection has occurred from the 125-member team, and this was a very subordinate man who had joined the team late, having come over from Germany only two years ago. So far, the original von Braun coterie of former German missile & rocket scientists remains intact, although von Braun himself and some of his associates have reportedly received upwards of 40 offers from as many outside firms.

Meantime, three well-known firms interested in missiles and rockets have inspected the 800,000 square feet of modern plant space available for purchase or lease following the demise of a cotton mill. All of these are firms which have been manufacturing parts, components and complete missiles.

The quantities of weapons that will be required by the 15 member nations of NATO will certainly give the Army new arguments for expanding its own development and research activities and perhaps also to build up at last its own industrial complex for the production of missiles and rockets and to create the private industry team, the lack of which has provided critics of the Army with potent arguments.

German Rocket Society Learns by Doing

The Deutsche Arbeitsgemeinschaft für Raketentechnik (DAR) of Bremen, although only two years old, is attracting wide interest in their activities. Headed by an enthusiastic engineer, A. F. Staats, the Society is investigating a number of applications for rockets. In addition to the "oil-spray" rockets (m/r April '57, pg. 88) liquid propellant and hybrid motors are being designed, built and tested. Sounding rockets built so far have reached only modest heights but the fact that all components, including gyro stabilization and recovery gear, have been produced by an amateur group is remarkable. Three-staged sounding rockets are being built to be launched during the IGY. Students joining the DAR are intensively drilled in basic rocket technology and principles of astronautics. Practical experience is gained as helpers and workers in constructing and launching.



German "do-it-yourself" experiment.

Measuring Devices Readied for Satellites

Two new measuring devices are being readied for future use as part of the astrionics gear to be carried in satellites.

Varian Associates, m/r learned, has just received the go-ahead to build a light-weight version of its proton precession magnetometer for measuring values of magnetic field encountered by a satellite during its orbit.

The magnetometer operates using the principle of nuclear magnetic resonance simultaneously discovered by Dr. Felix Bloch at Stanford University and Dr. Edward M. Purcell at Harvard University in 1946.

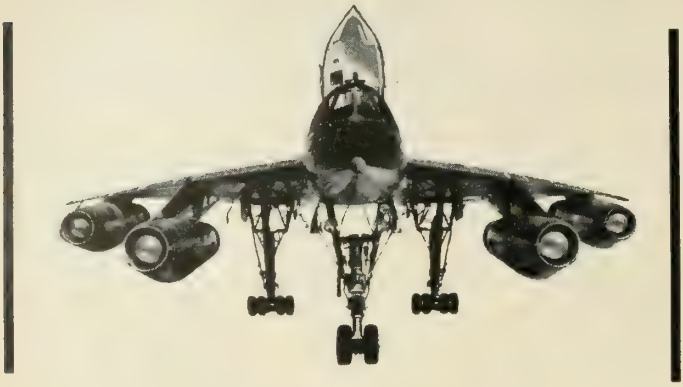
The two scientists were jointly awarded the 1952 Nobel Prize in Physics for their work which was done independently using different methods.

Varian's estimate of the satellite magnetometer's weight is about 4-4½ pounds with an absolute minimum of 3½ pounds. However, in a report by Varian to the Naval Research Laboratory it was noted that the device would not be ideal.

An ideal device would be able to record, with extremely high signal-to-noise ratio, all values of magnetic field during one trip around the earth.

The information would be recorded and then "dumped" upon interrogation from the ground when the satellite was over a recording station.

However, storage is a big problem at this time, and according to the report, storage of full magnetic field



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strength may not be feasible in the first tests. Instead, spot checks may have to be made.

A new development in high-capacity light-weight recording devices holds out hope for inclusion of such a system among early experiments.

The State University of Iowa has built a tape recording system that weighs 6½ ounces and has a 48 channel capacity. Bandwidth of the system is 15 kilocycles. Power supply for the recorder will last four weeks.

Another recorder suitable for satellite use has also been built by the Signal Corps. One of the primary scientific tests in which the Signal Corps is interested is measurement of the earths' albedo or cloud coverage.

New Transistors Developed by GE

Development and production of three new high frequency transistors by the General Electric Co. is expected to extend the applications for these devices in equipment now limited to vacuum tubes.

The three new units are germanium tetrodes and one is designed for amplification at 120 megacycles, according to GE.

Characteristics of the new 3N29, 3N30, and 3N31 types call for a minimum gain of 10 db at 30, 120 and 15 megacycles respectively. Dissipation is 50 milliwatts at 25 degrees C.

For local oscillator use frequencies are: 3N29-50-60 mc, 3N30-200 mc, 3N31-30-40 mc.

New Publication On Electron Tubes

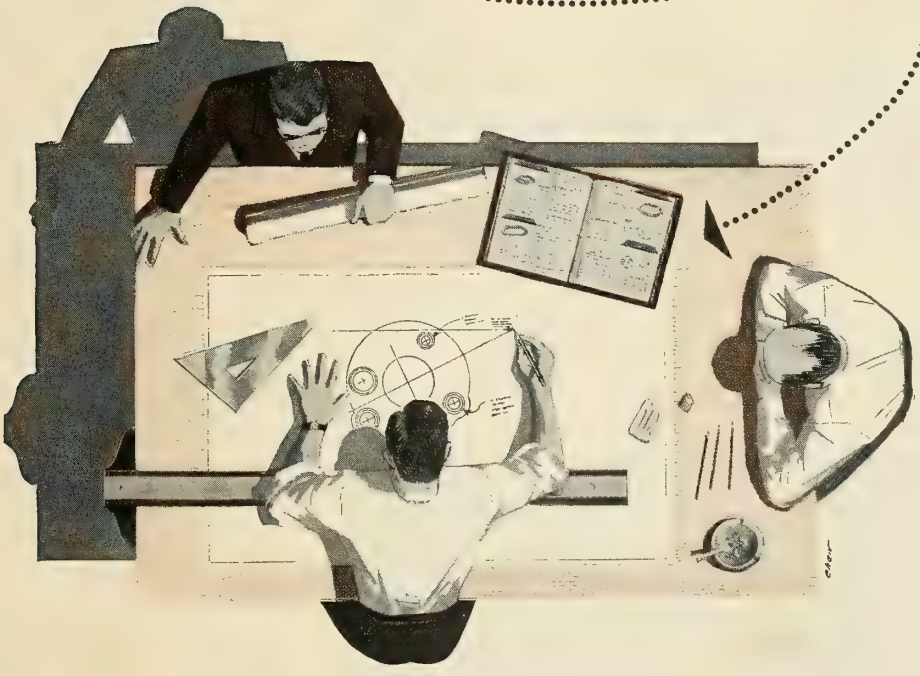
A new quarterly bulletin on electron tubes is being published to provide information to government agencies and contractors on research and development programs being sponsored by the military departments.

Known as *A.G.E.T. New Bulletin,* its publication began in January, 1957 to further objectives of the Advisory Group on Electron Tubes established by the Asst. Secretary of Defense (R&D) to achieve an integrated R&D program for electron tubes and semiconductor devices.

Information of a general nature which surveys state of development and new developments just started will be included in the *bulletin.*

Publication is by A.G.E.T. at 346 Broadway, New York 13, N.Y.

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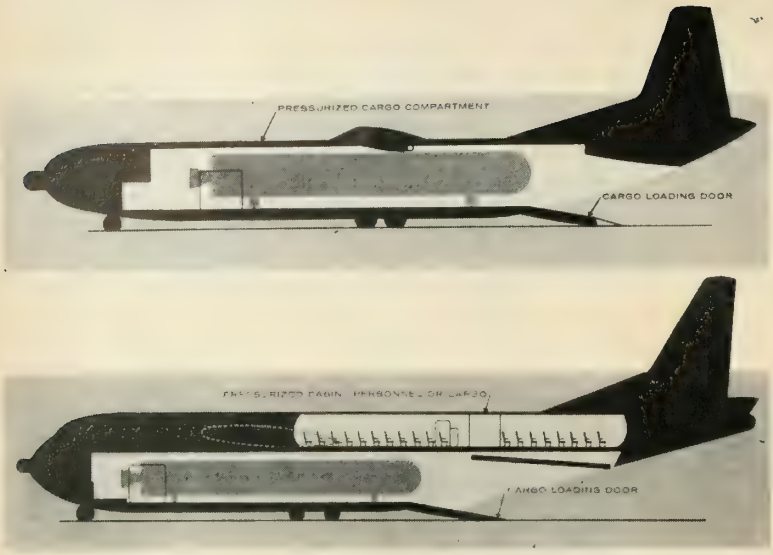
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Douglas Aircraft has made a proposal to the Air Force to build some new, giant-size transports capable of hauling an Atlas ICBM to any location in the world. Although WDD's General Ben Schriever is understood to be very much interested in the concept—appreciating the necessity for mobility in a future war—Air Force does not seem to have the funds for the king-size planes right now. No details on performance were given for the proposed aircraft, although some payload specifications have been discussed in the open. The larger version of the Douglas transports would be capable of hauling a complete Atlas and launching crew. Top picture shows C-133 now being built. C-132 is out for the time being. Both planes are turbo-prop powered.

Trajectory Analysis
for ICBM and IRBM

Flight Mechanics

Ballistics

Orbital Mechanics

Flight mechanics, ballistics, and orbital mechanics are among the areas in which there are current openings at Ramo-Wooldridge, where engineers and scientists are providing over-all systems engineering and technical direction for the Air Force Ballistic Missile programs. These positions are centered about the calculation and evaluation of missile trajectories, utilizing the services of a digital computation group. Trajectory determinations, in turn, affect missile systems design and flight test.

Education and experience should be in one or more of the following or related fields: aeronautical engineering...aerodynamics...flight mechanics ...performance analysis...rocket propulsion... applied physics...applied mathematics.

Inquiries regarding these opportunities should be addressed to: Mr. W. J. Coster

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GE Gets $83-Million *Atlas* ICBM Contract

General Electric Co. has announced receipt of a $83-million Air Force contract for "work in connection with guidance of the *Atlas* ICBM."

Role of GE's Heavy Military Electronic Equipment Department which will do the work was announced last year, but the size of the contract was not disclosed.

Also revealed was formation of a new Missile Guidance section of the HMEE department. R. L. Shetler will head the new section.

Shetler noted, "With this job behind us, there will remain no significant obstacles to the practical guidance and navigation of other space vehicles."

GE will divide the work between its Syracuse, N.Y. and Utica, N.Y. facilities. Additional space in Utica has been obtained, and 400 employees have been transferred there from the other Utica location.

Mich. U. to Hold Management Courses

University of Michigan will present a group of courses in management science and computer technology from August 19 to 30.

The short courses will feature a scientific approach to management decisions.

Attention will be focused on a comprehensive approach to planning, organization and control. These will include use of the digital computer, probability, statistical inference, methods of programming business operations and consideration of human capabilities and limitations.

Enrollment is limited to fifty students holding the equivalent of a four-year college course in business, engineering or science.

Transistor Output 59 Million by 1958

Latest forecast on the future transistor market has been released in a market survey made by the Stanford Research Institute for the Philco Corp.

The Stanford report included information supplied by 80 companies who cooperated in the survey.

Forecast was a production of 59 million germanium and silicon transistors in 1958, and 125 million units by 1959.

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MIT Discloses Work on Inertial Guidance

After 18 years of security classified work in the development of gyroscopic instruments, the Instrumentation Laboratory of MIT opened the door and disclosed some details of their work. At a press conference recently, Dr. C. S. Draper, Director of the Laboratory and head of MIT's Department of Aero Engineering, lectured reporters on basic elements of inertial guidance and showed examples of their Hermetic Integrating Gyro (HIG).

The Model HIG-3 contains a gyro wheel which spins at about 12,000 rpm within a cylinder which floats in a heavy molasses-like fluid within another cylinder. Overall size resembles a tomato can. The floating gyro container pivots on sapphire bearings which are virtually frictionless. It is the concept of the "floated gyro" that is considered a major breakthrough in gyro technology. A miniaturized Model 10-I-G weighs about 3 oz. Power requirements are only 3/8 watt permitting transistorized circuits. It is understood that in May the USAF will make drawings of this circuit available to manufacturers.

Although the principles of inertial guidance are decades old it is only recently that application of new technology has resulted in measurements of much smaller angles and accelerations. This makes the modern stabilized gyro system an important navigating device for military aircraft and the heart of a long range ballistic missile. As Dr. Draper pointed out: "It is not the system but the state of the art which is news."

The Instrumentation Laboratory is under MIT's Division of Sponsored Research. The Staff currently employs more than 700 working in laboratories in Cambridge and at a Flight Facility at nearby Bedford, Mass.

50-Ton Machine Tool Guided by Tape

Details of the first production application of a punched-tape control system to a huge machine tool, using electronics to process blueprint information and turn out precision-built structural parts, have been revealed by the Martin Co. and Bendix Aviation Corp. The new system will be used in aircraft and missile manufacture at Martin's Baltimore division.

Built to Martin specifications by the Research Laboratories division of Bendix, the new system is a 50-ton, three-dimension (engineers call it three-axis) milling machine with associated electronic equipment that eliminates the need for hand-made patterns or master parts which themselves normally require several hundred man-hours to produce.

Dr. Albert C. Hall, general manager of the Bendix Research Laboratories division, explained that the tape-controlled process, technically known as "numerically controlled milling," was first used in mass production by Bendix to solve a bottleneck in the manufacture of a small, intricate cam that is one of the key parts of a jet engine fuel-metering system. In this instance, production of a "master cam" was a one-man job requiring from 5 to 10 weeks of highly skilled work. With the tape-control process, that operation can be completed in from two to four days.

New Electronics Firm is Organized

A new corporation, Era Engineering, Inc., has recently been formed by a group of scientists and engineers with aircraft and missiles industry experience. The company says its objective will be the development of new systems and devices in the fields of electronics, radiation and rocketry. Office facilities and laboratories have been located in Santa Monica, Calif.

The group, headed by Mr. David Shonerd, announces three new systems now available: (1) A simple system for measuring the distance between a missile and its target in a "near-miss" situation; the system will assess the effectiveness of missiles under experimental firing conditions and information will be available to firing crews immediately after impact, (2) a device for measuring the erosion of materials on missile surfaces under hypersonic environments; also available will be a complete system for measuring and recording the thickness of a skin material as a function of time, and (3) a radioactive recovery technique to mark and insure recovery of missiles and missile components after experimental flight.

ARDC Sponsors "Smoke Puff"

Operation Smoke-Puff will begin in July this year at ARDC's Holloman Air Development Center. An extension of earlier tests, Smoke-Puff will constitute a detailed analysis of the effects of a man-made electron or ion cloud upon high-frequency radio signals.

No ordinary **Dynamicist** will do for this job...

The engineer we need has superior creative ability and an analytical mind. He now has senior status—a Mechanical, Chemical, Electrical Engineer or Engineering Physicist (preferably with advanced degree) who is versed in classical vibration analysis, as well as feedback analysis for control of systems composed of Heat Transfer, Fluid Mechanics and Thermodynamic processes.

Dynamical system of the High-Thrust Liquid Propellant Rocket Engine is one of extraordinary interest, exceptional performance. No matter what your achievements have been, you'll find new interests at Rocketdyne. You will be confronted with the analysis of design and operational problems of the rocket engine as a dynamic system. You must develop valid mathematical models of both systems and components, using advanced physical concepts and empirical data. These must be combined using digital computation and analog simulation.

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A DIVISION OF NORTH AMERICAN AVIATION, INC.

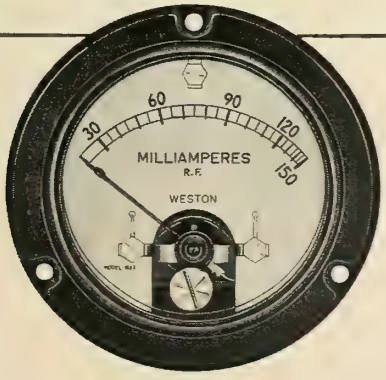
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Expanded facilities now make Weston ruggedized instruments readily available for A-C or D-C needs in a variety of sizes and ranges. For the complete story, consult your local Weston representatives, or write . . . WESTON Electrical Instrument Corp., Newark 12, N. J.

French *Monica* Rocket Performs Well at Low Cost

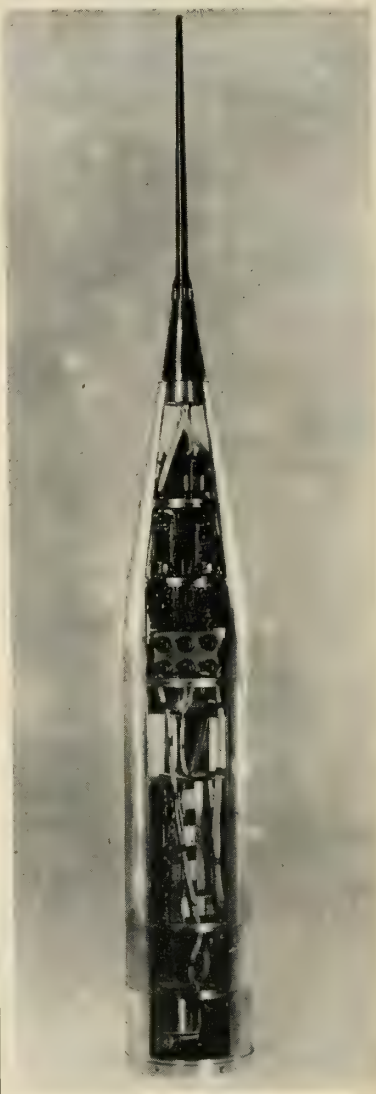
Designated the *Monica*, the French A.T.E.F.-14 series of three-stage sounding rockets have been undergoing development for more than two years. Utilizing a solid propellant, designated "plastolite," these rockets are notable for high performance, simplicity and low cost. Payloads of up to 33 lbs. have been carried to altitudes of over 300,000 ft.; 17 lbs. to nearly 500,000 ft. The cost per unit is 500,000 Francs (about $1,400). These facts indicate that French development of the art of low cost sounding rockets compares favorably with current U.S. work.

Four Models of *Monica* have been built to date. Characteristics and performance are detailed in the Table shown. In each of the first three models, two designs were tried, Type A in each case carrying double the payload of Type B. *Monicas* have a diameter of 6¼". Lengths vary from 10 ft. to nearly 18 ft.

Construction is relatively simple. The rocket body is of dural about ¼ in. thick. The rocket motor is of steel with a graphite nozzle. The individual stages are mounted in a slip-joint fashion.

The design thrust of the first stage is sufficient to take off from the launching ramp and achieve a velocity above Mach 1 in less than 5 seconds. Ignition of second and third stages is governed by time-delay relays designed to obtain maximum altitude. The rockets are shipped with propellant loaded. Ignitors and upper-stage firing relays are installed just prior to launch. Firing circuit runs on 12v. battery.

Monica's normal payload consists of instrumentation such as accelerometer, aneroid capsule, pirani gauge, and/or cosmic ray measuring devices. Telemetering is accomplished on AM-FM bands of 4-6 channels. Other research programs contemplated or underway include experiments with animals (recovering by parachute), temperature probes and release of chemicals in the ionosphere to study the resultant reactions. Firings have also been made with "window" to study the nature of winds and tracers to measure trajectories accurately.



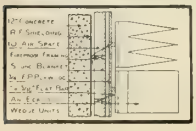
MONICA instrumentation.

TABLE OF CHARACTERISTICS AND PERFORMANCE OF THE *MONICA* SERIES OF ROCKETS (A.T.E.F.-14)

	MONICA I		*MONICA II*		*MONICA III*		*MONICA IV*
	Type A	*Type B*	*Type A*	*Type B*	*Type A*	*Type B*	
Dimensions							
Length (in.)	11' 10"	9' 10"	12' 10"	10' 11"	17' 9"	15' 11"	16' 10"
Diameter (in.)	6¼"	6¼"	6¼"	6¼"	6¼"	6¼"	6¼"
Weights (lb.)							
Launch	154	136	172	156	276	260	271
Propellant ("plastolite")	62	62	74	74	137	137	136
Payload	33	15.4	33	16.7	33	17.6	33
Total Burning Time (sec.)	23	23	25	25	25	25	25
Acceleration, max. (g)	9.8	10.56	8.7	9.7	11	11.7	11.3
Performance							
Velocity, max. (ft./sec.)	2540	3240	3570	4550	4420	5290	4550
Altitude, max. (ft.)	120,000	173,500	220,500	339,000	347,000	475,000	307,800
Time of ascent (sec.)	93	112	129	158	158	184	152



Detail of five foot thick anechoic wall construction.



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. . . at Westinghouse Sharon, Pennsylvania.

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Sound studies on transformers up to 500,000 KVA capacity are made in this huge anechoic chamber, the interior of which was fabricated and erected by The Eckel Corporation.

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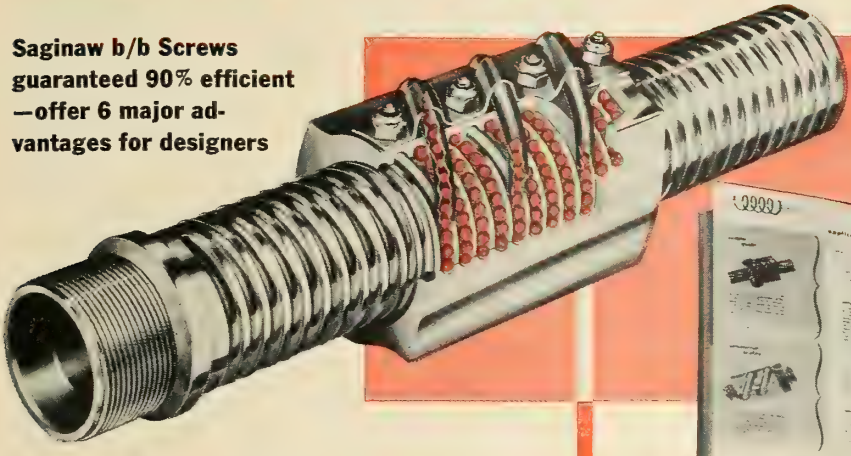
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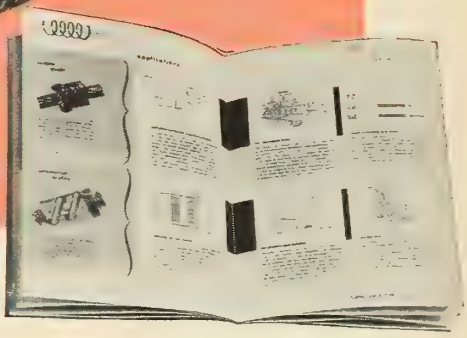
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ACTUATION PROBLEM too tough for ordinary devices?

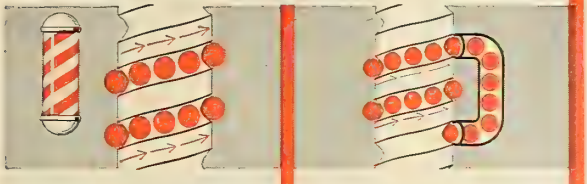
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Saginaw b/b Screws guaranteed 90% efficient —offer 6 major advantages for designers





Available in custom machined and commercial rolled thread types—have been built from 1½ inches to 39½ feet long—⅜ to 10 inches diameter.



Nut *glides* on steel balls. Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.

At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

1 VITAL POWER SAVINGS. With guaranteed efficiency of 90%, Saginaw b/b Screws are up to 5 times as efficient as Acme screws, require only ⅕ as much torque. This permits much smaller motors with far less drain on the electrical system. Circuitry is greatly simplified.

2 SPACE/WEIGHT REDUCTION. Saginaw b/b Screws permit use of smaller motors and gear boxes; eliminate pumps, accumulators and piping required by hydraulics. In addition, Saginaw b/b Screws themselves are smaller and lighter. Units have been engineered from 1½ in. to 39½ ft. in length.

3 PRECISE POSITIONING. Machine-ground Saginaw b/b Screws offer a great advantage over hydraulics or pneumatics because a component can be positioned at a predetermined point with precision. Tolerances on position are held within .0006 in./ft. of travel.

4 TEMPERATURE TOLERANCE. Normal operating range is from −75° to +275° F., but assemblies have been designed in selected materials which function efficiently as high as +900° F. These units are practical where hydraulic fluids have lost efficiency or reached their flash point.

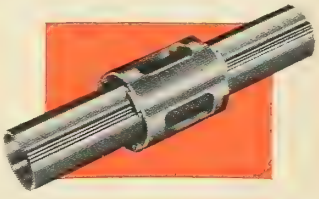
5 LUBRICATION LATITUDE. Even if lubrication fails or cannot originally be provided because of extreme temperatures or other problems, Saginaw b/b Screws will still operate with remarkable efficiency. Saginaw units have been designed, built and qualified for operation without any lubrication.

6 FAIL-SAFE PERFORMANCE. Far less vulnerable than hydraulics. In addition, Saginaw offers three significant advantages over other makes: (1) Gothic arch grooves eliminate dirt sensitivity, increase ball life; (2) yoke deflectors and (3) multiple circuits provide added assurance against operating failure.

YOUR FREE COPY OF THIS NEW b/b SCREW AND SPLINE "PROBLEM SOLVER" SHOWS HOW

36 pages crammed with time-, work-, and money-saving facts: Principles • Types • Basic Operations • Coupling Methods • Efficiency • Advantages • Selection Factors • Design Data • Sample Problems

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● Averages 40 times lower coefficient of friction than ordinary sliding splines!

Utilizing the same basic *gliding ball* principle, Saginaw has developed the *Saginaw b/b Spline* which radically increases the efficiency of transmitting or restraining high torque loads.

It can be fitted with integral gears, clutch dogs, bearing and sprocket seats, etc. Units have been built from 3 inches to 10 feet long—⅜ to 6 inches in diameter.

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ROCKET POWER PROGRESS REPORT

Taming Rocket Powerplants

by Walter O. Borcherdt



In charge of the Engineering Development Laboratory as well as the Valves and Controls Section at RMI, Mr. Borcherdt has over a decade of rocket experience. Before coming to RMI in 1951, he was senior project engineer on controls in the rocket department of Curtiss-Wright Corporation. Mr. Borcherdt received his degree in mechanical engineering from Stevens Institute of Technology in 1938.

Reliability of a rocket powerplant is the direct result of the simultaneously correct operation of all of its elements. Generally, this is assured by overcoming each element's own peculiar development problems. Among these elements is one type which has the interesting property of being composed of specific components, yet whose operational characteristics are significant only in the performance of the entire powerplant system. This element is the control system.

Present powerplant controls requirements are based on these straightforward, simple considerations:

1. **Prepare the powerplant for firing**
2. **Sequence and control the system to rated thrust**
3. **Vary thrust rapidly and safely as required**
4. **Shut down smoothly**

Step one may require the use of gas pressure regulators and relief valves to push the propellants safely from tankage to pumps. There must be switches and relays to indicate or control the valves which admit propellants to the gas generators and combustion chambers, and time delay cutouts to insure against unsafe accumulation of propellants.

In step two, ignition and combustion may be monitored to insure correct use of the high energy release rates. Turbines may be safely brought up to speed by throttling the propellants. Safety devices may be added to limit over-speed and avoid the danger of structural failure.

In step three, a controller (it may be hydraulic, electric, pneumatic, or a combination) is used to vary thrust. Here multiple loop servo systems are sometimes used to insure that thrust change rates, turbine speeds, vehicle acceleration or terminal velocity, and other parameters vary in a coordinated manner.

Finally, in multiple stage powerplants or piloted vehicles, the rocket engine must be shut down safely and the system automatically purged of propellant accumulations.

The successful implementation of these four steps involves the application of many devices of unique characteristics whose individual selection is intimately tied to the following question:

"What is the actual control system problem to be solved?"

Once this question is clearly and consistently defined, a tight performance envelope results. This makes the few possible solutions fairly obvious. The final stage is to apply the knowledge of a team of control specialists and proceed through the usual component development stages. At RMI, this team of specialists in controls engineering is made up of highly qualified mechanical, electrical and chemical engineers. These professional men have wide experience in the creation of control units and systems for rocket powerplants as well as other types of propulsion systems. However, there is a continuing need for qualified graduate engineers, able to participate in working closely with other groups of specialists, integrating the control system into the overall engine performance envelope.

The systems approach is of extreme importance to successful rocket powerplant control efforts. It is a standard approach of the RMI Controls Section. Sequence system design, switching circuit analysis, human engineering, feedback control methods, statistical procedures, information theory and latest research data on fluid flow control are among the techniques used. They are applied along with practical design concepts which result in the development of simple but effective controls systems.

If you desire one or more reprints of Mr. Borcherdt's article, or would like to receive further information about employment at RMI, write to our Information Services Coordinator. Reaction Motors, Inc., 16 Ford Road, Denville, New Jersey.

Power for Progress
RMI

Russians Backtrack On *Mouse* Origin

The Russians seem to have been embarrassed by m/r's disclosure last November that a Soviet magazine was guilty of satellite design plagiarism. They appear to be making amends. m/r pointed out that a cross-sectional schematic satellite drawing attributed to engineer B. Lyapunov and artist N. Antonov was an exact copy of one of Dr. S. Fred Singer's early *Mouse* versions. Now engineer Lyapunov has written a new two-page article on foreign rocket and earth satellite developments for the Russian magazine *Znanie-sila* (Knowledge Is Power). In it, Lyapunov uses virtually the same artificial satellite drawing that bore his name in the previous story. But this time he gives Dr. Singer full credit for the design both in the picture cutlines and in the article's text.

AF to Track Drones With Decca System

According to a report from an industry source, the Air Force is planning use of a Decca Navigator system to keep track of its target drones.

The drones would be equipped with Decca equipment to receive signals similar to those used in Great Britain for air and sea navigation.

Drones which "go over the hill" would transmit Decca coordinate information to search crews through telemetering equipment onboard. Exact location of the drone could be quickly determined.

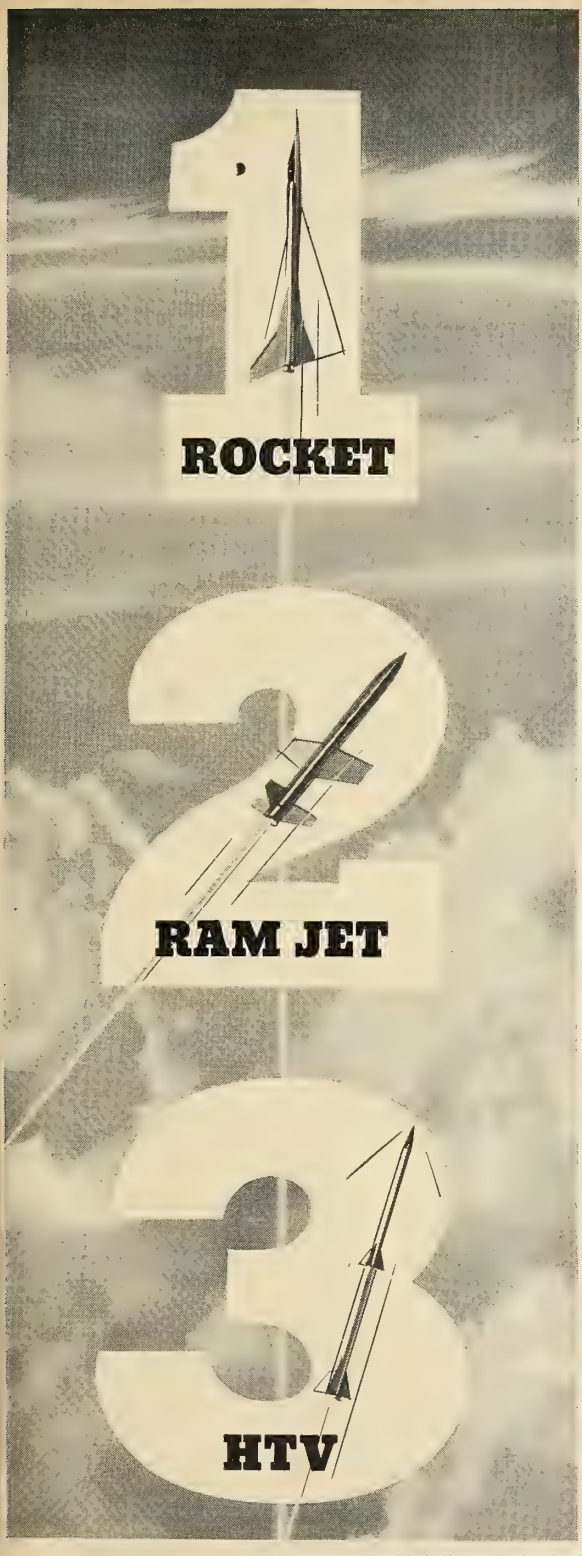
Equipment would be supplied by the Bendix Pacific Div., Bendix Aviation Corp. which supplies Decca Navigator Co., Ltd. equipment in the U.S.

IRE Convention To Meet in June

A National Convention will be sponsored by the IRE Professional Group on Military Electronics in Washington, D.C. on June 17-19, 1957.

Admiral W. E. Cleaves, Bendix Radio Division, Bendix Aviation Corp. will chair the convention which will theme "Missiles and Electronics."

Appointed to the executive committee as staff advisors for the convention are assistant secretaries of defense Frank Newbury and C. C. Furnas.





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powerplants and missiles set new performance standards for tomorrow

A Curtiss-Wright Rocket Engine recently powered an aircraft higher and faster than man has ever flown before. A Curtiss-Wright supersonic Ram Jet Engine was the first controlled supersonic ram jet to be successfully flown – and advanced versions are now being developed for piloted aircraft and guided missiles. A Curtiss-Wright hypersonic test vehicle – the HTV Rocket – recently reached supersonic speed in a fraction of a second . . . developed several times the speed of sound in just two seconds.

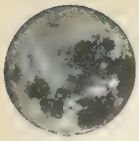
These developments—all capable of several times the speed of sound – are the advanced guard in America's defense, and in America's research toward the high speed, high altitude air travel of tomorrow. They are dynamic evidence of Curtiss-Wright's leadership in the aviation industry – setting the pace for aviation's progress in *every* category of air power.

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Missile Miscellany

This page is politically independent but skeptical . . . so it wonders:
——If it's to use up surplus funds that Post Office is investigating the possibilities of rocket mail service . . .
——If Defense Secretary Wilson, wandering about Patrick AFB and possibly holding his ears against Jupiter's roar, may have decided after all to learn something first-hand about missiles . . .
——How many realize how ineffectual true military security is; how effective Pentagon censorship has become; how it helps Uncle Joe's heirs and how it hurts Uncle Sam's . . .

The other night at a philosophical function, an ICBM propulsion engineer asked this page: "The missile's here to stay, but is man?" . . . and from an atom editor emeritus, a quip about Pentagon Security Review: "A certain type of cat gravitates to the job.'' . . . and a simple explanation of things complex by Commerce Undersecretary Louis S. Rothschild before House Appropriations Subcommittee: "In other words, the whole purpose of SAGE is to bring aircraft together, so that they can hit one another with ballistic missiles of one kind or another"—at last a mission for Jupiter? That same evening a Relativity novitiate wondered if anyone had ever stepped back and looked at the velocity-dependent approach of mass to infinity as a drag effect in an as yet undetected medium.

To prove that truth is stranger: Once upon a time an AF general telephoned m/r to ask: "What are you, an Army house organ?" And it came to pass within a fortnight it was heard from out the jungles of commerce this charge by an Army-contracted advertising prospect: "You're just an Air Force house organ!" After this issue of m/r, what?

Missile has now been defined as an "airplane which saves manpower by eliminating the pilot but takes 372 men to launch . . ." And a classified missile as "one which only a news magazine may print a picture of . . ."

The limiting problem in inertial guidance accuracy are the integration circuits (giving a series result) needed to transform inertially measured acceleration into velocity and then distance. One answer that works eliminates one integration step by using thrust control to fix velocity.

About faces—this page just heard about SAC Chief General Curtis LeMay's when first he saw movie of Sidewinder disappearing up jet tailpipe—also after he was assured it too could be given nervous breakdown . . . more on ECM reveals it's essential sometimes to drop the "E" and in same business to make sure nobody pushes wrong button and sucks attacker into target it's planned to take the fingers out of pushbutton warfare . . . still more on the unessentiality of man, a computer now watches other computers; reports every so often with complete psychoanalysis of its charges' troubles . . . then there's the early Bomarc test when condensation gave full nose down reading (that wasn't) and "corrective" control caused it to do two inside loops and whoomp smack alongside blockhouse . . . B-52's sometimes troublesome gun turrets are to be replaced with missile batteries . . . and talk too this page hears of radar invisibility . . . still serious, talk in high quarters of supersonic underwater flight—over 2700 mph . . . work at Aerojet on rocket torpedoes that top 140 knots—which may be related to Minneapolis-Honeywell guidance for "long-range" torpedoes and GE sonar detection gear good well over 100 miles . . . an expert says we know less about the ocean than we do surface of the moon . . . GE missileman sees rocket on moon with instruments and transmitter (look ma, no men! again) inside 20 years—whatsa delay! . . . if plankton dreams of oceanographers come true, to right is hydroduct fuel of the future . . .





Rocket Trends

By Erik Bergaust

When we let our editors, correspondents and contributors loose on the subject of underwater warfare, submarine missiles and torpedoes, we learned one thing: the United States Navy is doing a tremendous job in this field—but industry is not at all aware of the fantastic possibilities that this field offers. True, many companies are working intensively on many sophisticated undersea warfare projects, but we found—nevertheless—that some of the most potential missile manufacturers did not even comprehend the concept of underwater missiles!

On the other side, we think it is appropriate to mention that many of the companies actively engaged in underwater missiles are so deeply involved in top secret work that the matter of covering their activities editorially was out of the question. But let us mention a few of them—without disclosing what they are doing—*Fairchild, General Electric, Convair Pomona, Raytheon, Coleman Enginering, Philco, General Mills, Minneapolis Honeywell, Brush Electronics, Clevite Research, Aerojet, Avco* and many others.

Yet, a good portion of what this country is doing in the field of underwater missile and submarine warfare is disclosed in the columns of this issue. As our publisher has pointed out in his editorial, this was made possible through the kind cooperation of Navy's Security Review Office. Perhaps we have only revealed a fraction of what's going on in this country—at any rate, let it be a warning to Russia's submarine commanders and their bosses in case they should be dreaming of a big surprise submerged mass attack on this country.

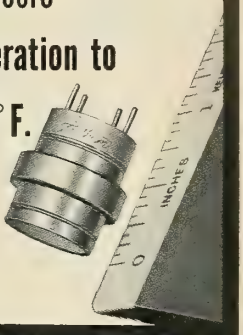
Our Navy is the number one marine defense force of the world. And in view of its meticulous efforts to advance itself in this field of silent, submerged warfare, and its awareness of the Red submarine threat, we can only invite industry to back our Navy in these efforts. It is crystal clear now that any Russian attack on this country will be a combination air-underwater assault. Her 500 to 600 submarines, eventually, would be used as missile launching platforms off our coasts. This is a rough threat—and a horrible thought—and we may not be prepared for this sort of thing. On the other hand, we have no reason to believe that Russia has perfected her entire submarine missile fleet and that she is ready for this kind of attack. And whenever she does get prepared we shall be equally capable to deter any such aggression.

The concept of undersea missiles is not new, but the application of such weapons is. Consequently, we have a long way to go. That's why industry must wake up right now and accept this important challenge. That's why inventors and designers must offer their ideas and suggestions now—so that our underwater early warning systems of the future and our anti-submarine weapons and missiles will be as supreme and deadly as our ballistic and anti-aircraft missiles.

We cannot tell now whether tomorrow's underwater super missiles will be propelled by solid rockets, electric motors, turbines, or what; we don't know whether they will be sonar-guided devices, or whether they will employ completely new guidance concepts. That's why there is room for a vast amount of research and development in this field, and that is why the goal of bringing about superior underwater missiles—whether they are designed to knock enemy planes out of the skies, or hit enemy subs or surface targets—should be pursued by every missile engineer.

This is the eighth issue of m/r. It is the second Navy issue. For good reasons. In fact, we now have published two Navy issues, two Air Force issues and one Army issue. Next? We have a vast field to cover. So we shall leave the services for a while and concentrate on the industry itself.

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Washington Spotlight

By Henry T. Simmons

Flight test results for major new missiles are pouring into the Pentagon at a rapid clip as the tempo of firings picks up at Patrick AFB, Fla. The flood of data brings with it a new problem which may increasingly concern the military services and their civilian directors: how well does the tax-paying public and its press understand the basic philosophy of the missile flight test program? After hearing for many years the loud claims of the excellence of this or that service's weapons, it is not surprising if the public has become confused about the missile program, and even a little disgusted, as newspaper reports crop up headlining the explosion of a *Jupiter* or the failure of a *Thor*.

•

The purpose of a missile flight test program, in a nutshell, is to make the bird fail under informative conditions. Paradoxically, the missile which sticks to its flight plan is not providing information as valuable as the vehicle which blows up on its launching stand under circumstances which can be analyzed, duplicated and then obviated for all time. Keeping this in mind, it is easy to see that most of the recent firings at Patrick have been "successful" from a test standpoint, even though they would have been abject failures if they occurred on the battlefield.

•

The "big one" which Defense Secretary Charles Wilson saw fired at Patrick last month was the second flight test of the Army's *Jupiter* mid-range ballistic missile. The power lasted less than two minutes, with the bird apparently "failing" under circumstances similar to those in which its predecessor was lost earlier this year. One theory is that an eddy current formed by air blast at the skirt of the big missile drew rocket exhaust flame up around the base of the weapon and burned out some wiring.

•

A jittery range safety officer brought the second flight test of the Air Force's *Thor* mid-range ballistic missile to a sudden end in April. In a flight of about 40 seconds' duration, the big Douglas missile was sluggish in responding to its auto-pilot and appeared headed toward the mainland. Mindful of the time an Army *Redstone* fell on a nearby launching pad (thus becoming the world's first Inter-Pad Ballistic Missile), the safety officer detonated the *Thor* before it could do any damage.

•

North American's rocket-ramjet *Navaho* intercontinental missile also got a second test flight about mid-March, it was learned. Despite grave and almost comical difficulties, it succeeded in demonstrating two major features of its operation—booster separation and ramjet ignition. The big bird accidentally carried part of its launching apparatus away during firing. Air blast finally tore loose the unwanted super-cargo, but this caused the booster to lose thrust. Nevertheless, the booster engine separated as programmed and there is evidence of ramjet ignition before the XSM-64 test vehicle plunged into the sea.

•

Look for the Air Force to seek Defense Department authorization for a prototype development program for the WS-110 manned bomber sometime next fall. This is the successor to the B-52 which Boeing and North American are presently working on. The airmen won't succeed without a battle, however. One Pentagon official says privately he will object to a WS-110 hardware program until an engine is clearly in sight which can use high-energy fuel. There's also the matter of money. Military spending during the current fiscal year is likely to hit $38 billion—$2 billion more than the Administration predicted in January—and the Pentagon will be inclined to go slow on ultra-expensive new projects.

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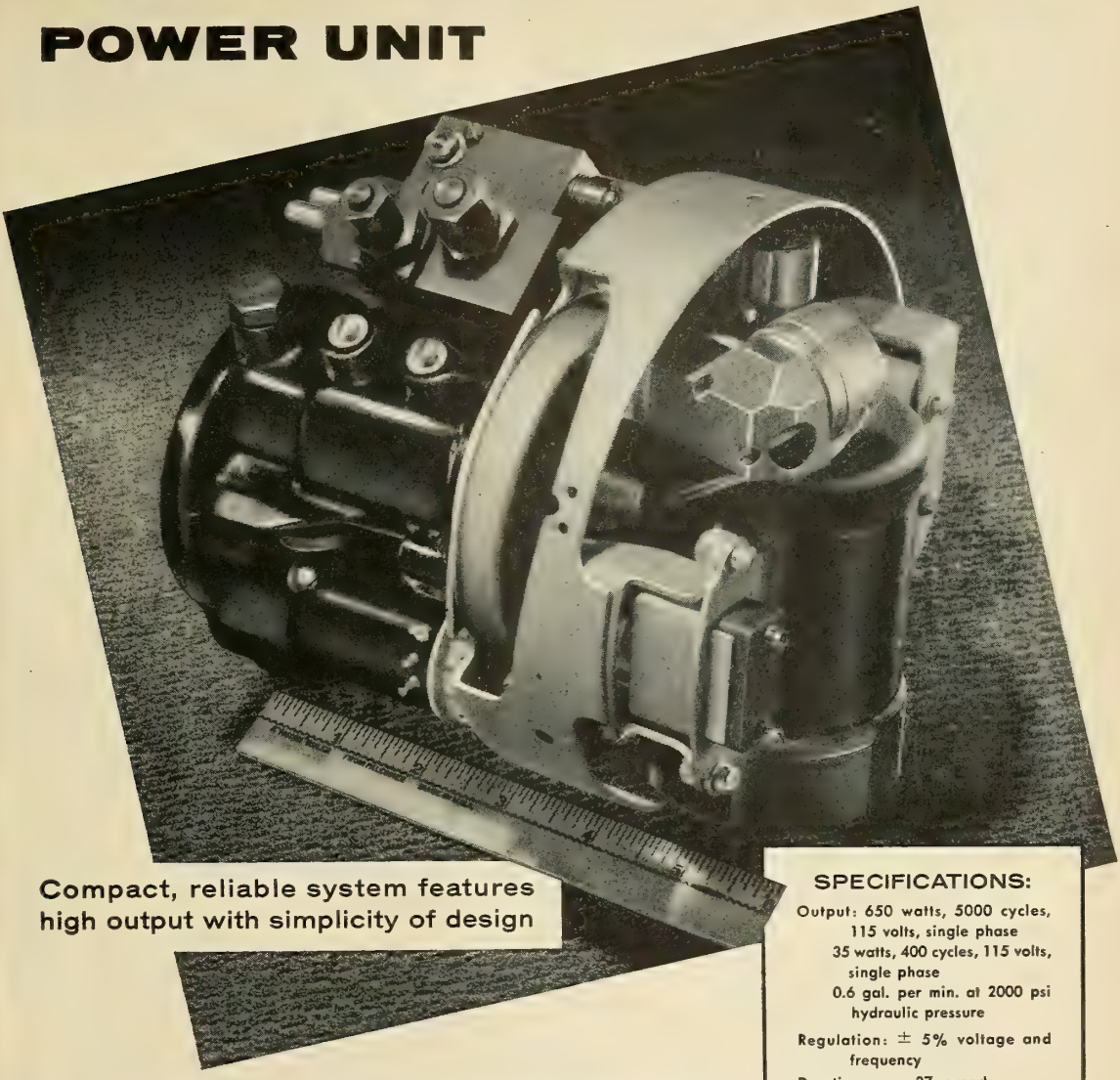
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This auxiliary power system is an example of AiResearch capability in the missile field. Inquiries are invited regarding missile components and sub-systems relating to air data, heat transfer, electro-mechanical, auxiliary power, valves, controls and instruments.

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What does it do between

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THERE?

For the first time the behavior pattern of a free space Moving Target can be directly calibrated and immediately evaluated!

The proof of any guided missile is its performance. Not only is it necessary to provide accurate trajectory data in order to determine its effectiveness, but this must be made immediately available.

To meet both requirements is the purpose of the AN/FPS-16 instrumentation radar. This is the first radar developed specifically for Range Instrumentation. It has demonstrated its ability to track with accuracy in darkness, through clouds—under any atmospheric conditions—over extended ranges, and to yield data that can be reduced almost instantaneously to final form. This unit can also be assigned to plot performance of missile, satellite, drone and other free space moving targets.

In the past, this data has depended upon optical devices, triangulation systems with long base lines and precision limitations, modified radar equipment and data reduction methods often requiring months for computation. The immediate availability of data evaluation provided by the AN/FPS-16, now being built by RCA under cognizance of the Navy Bureau of Aeronautics for all services, is a great forward step in Range Instrumentation.

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VOL. 2 NO. 5
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missiles and rockets
MAGAZINE OF WORLD ASTRONAUTICS

m/r exclusive:

UNDERWATER MISSILES

A New Lethal Dimension in Unmanned Warfare

by Comdr. Charles W. Rush

AS A MEANS of delivering weapons against targets at sea or on land, the submarine possesses unique advantages over other weapon system. Cruising beneath the radar and visual detection stratum, somewhere in thousands of cubic miles of ocean volume, the submarine is not readily susceptible to being destroyed by surprise attack.

The advent of nuclear power has greatly enhanced the capabilities of the submarine. In addition to the almost unlimited submerged endurance and high speed which it contributes, nuclear propulsion makes the submarine a true all-weather ship. Not only can the nuclear-powered submarine ride out the worst storms in comfort and safety, it also can navigate under the Arctic ice-pack at any time of the year.

With the post-war change in the submarine forces' primary mission from destroying surface ships to sinking enemy U-boats, the requirement for a submarine-launched anti-sub weapon became paramount. Even the best anti-surface torpedo could not meet this new requirement—the problem had expanded into a new dimension.

Intensive research was applied to find a solution to the three-dimensional attack situation. The answer to this difficult problem was found in the conception of a homing torpedo that would guide itself to the noise emitted by a moving submarine. While this weapon unerringly seeks out a target sub, it is equipped with safety devices to protect the firing ship.

Another underwater-to-underwater weapon—one with a delayed action—is the submarine-laid mine. The submarine can first determine its exact navigational position, then lay these deadly "eggs" from its torpedo tubes in the location where they will do the most damage to enemy ships. Mobile mines have been developed which permit the submarine to remain outside an enemy harbor, while planting a minefield several miles distant.



After the war, the Navy recognized that the combination of the submarine and the guided missile would provide an effective system for deterrence of large scale aggression. In order to gain immediate experience with this system, the *Loon* missile, a modified German V-1, was fitted for shipboard.

Two submarines, *USS Carbonero* and *USS Cusk,* were equipped with launchers and radio command systems for guiding *Loon.* These early operations provided valuable experience, training, and testing for application to the higher-performance submarine missile systems which were to follow.

In 1947, the Navy initiated a program with the Chance Vought Aircraft Co. to develop a guided missile for launching from submarines. The result was the *Regulus,* a swept-wing, turbojet-powered, transonic missile capable of delivering an atomic warhead to a range of 500 miles. Two submarines, *USS Tunny* and *USS Barbero,* were converted to carry *Regulus* missiles.

In 1956, the Navy decided to complete the attack submarines *USS Grayback* and *USS Growler* as guided missile submarines. At the same time, construction was started on the first nuclear-powered guided missile submarine, *USS Halibut.* All of these submarines are designed to carry the *Regulus* missile.

Testing is now underway on *Regulus II,* a longer-range, supersonic replacement for the original *Regulus* missile. The configuration of all new air-breathing surface-to-surface missiles will be compatible with the new guided missile submarines, in order that the different missiles can be used interchangeably. This planning will expand the missile delivery capability of the new guided missile submarine. It will also extend the useful life of the submarine beyond the life of any one particular missile design.

(Ed. Note: To follow up the REGULUS II the Navy has the Triton development program, a Mach 4.0, 1500-mile range ramjet powered missile that will fit Regulus launching gear with only minor modifications.)



Spinning ball entering water at high speed leaves cavitation wake of water vapor similar to aerodynamic turbulent flow, exemplifying major underwater weapons system problem.

In addition to the air-breathing guided missiles, the Navy is working at high priority to develop a rocket-powered ballistic missile which can be launched from submarines. This is not an ultra-visionary weapon; its accomplishment is entirely within the current capacity of our missile technology.

One of the major areas requiring intensive development for successful utilization of long-range ballistic missiles is precise, all-weather navigation. Various new equipment being tested in the *USS Compass Island* promise to provide means of attaining the required accuracy, even under the darkest overcast conditions.

(Ed. Note: There are several approaches to precise underwater navigation. One might be the use of inertial systems similar to those now being developed for long range ballistic missiles. Another is the establishment of precisely located beacons on the ocean floor which could be "shot" the way aerial missiles now shoot the stars.)

Our subs are equipped with two types of sonar: active and passive. Active sonar is capable of determining both range and bearing of submerged targets, but it must send out detectable energy to do this. Passive sonar does not transmit energy to the water, but furnishes target bearing information.

Against fast-moving targets, an automatic computer is needed for rapid analyzation of target and firing-submarine data. The trend in computer design is to equipment which resembles an electronic "brain." It must receive inputs from the sub's gyro-compass and underwater log, select data from the radar or sonar, perform complicated mathematical calculations in a fraction of a second, digest the data, predict the target's position on weapon arrival, and aim the weapon.

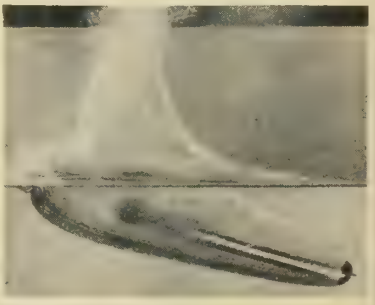
With the captain's permission, which he may give by throwing a switch, the computer can actually fire the weapon. Remarkably, computers have traditionally been one of the most reliable elements in our submarine weapon systems.

Future, foreseeable advances in submarine performance will place great demands on anti-submarine weapons. Submarines will run faster and deeper; weapons against them must follow. Our own submarines will be able to operate in the depths where enemy subs can be detected most readily; they must be equipped with weapons that have a high probability of sinking the high-performance submarine.

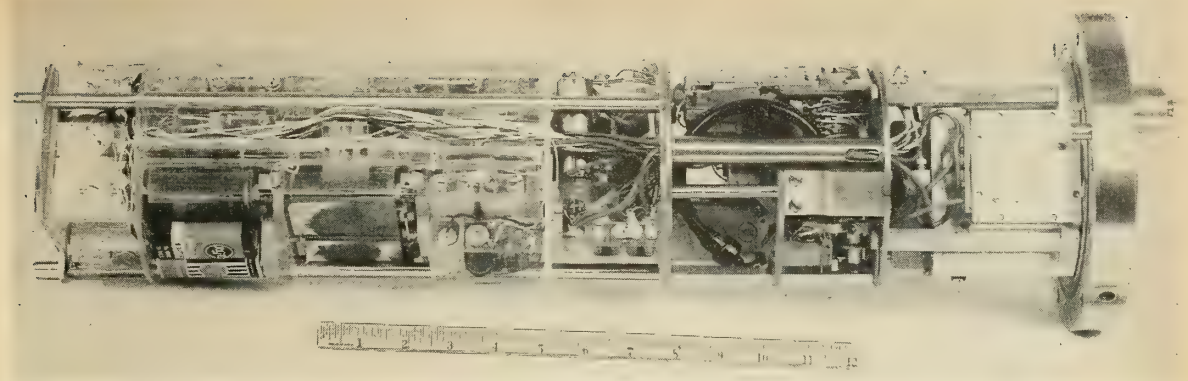
First, in order to minimize the time during which the target can evade and to reduce pursuit time after acquisition is made, advanced undersea weapons must be able to make high







A major hydrodynamic problem with torpedoes is that they may cavitate and



Showing that underwater instrumentation is not dissimilar to that required for airborne missiles, this assembly is used for studying the depths of the ocean. From left to right are: the battery and voltage regulator assembly; next, in order, comes the depth marker and pulse generator telemetering tube assembly and telemetering deck including servo-control tube for photomultiplier, pressure (depth) bourdon and linkage to microtorque potentiometer, function selector rotary stepping switch, ratchet relay, access plate to sealed photomultiplier and assembly aligning pin. A detailed study of the ocean's characteristics is vital to the successful development of modern underwater weapons systems.

speed. Secondly, as the maximum range of underwater detection equipment is increased, weapon range must be augmented to match. Enemy subs must be taken before they can strike.

At torpedo speeds greater than approximately 50 knots, the screw propeller's efficiency and ability to transmit power to the water decreases rapidly. This is caused by cavitation, which also causes radiated noise to increase substantially. To overcome these difficulties, very-high-speed torpedoes must be designed with optimum hydrodynamic form and jet propulsion.

Underwater jets may be of two general types: rockets and hydroducts, corresponding to rockets and air-breathing jets in the atmosphere. The disadvantages of rockets for underwater - to - underwater applications are that they must carry all of the mass required for propulsion and that their velocity and efficiency are limited by the resistance of the viscous medium. In order to gain high speed while retaining long range, underwater jet propulsion vehicles will probably utilize the hydroduct principle, which uses ambient water to increase the mass flow rate.

Even jet-propelled torpedoes have practical speed limits, which will be reached when their velocity causes the waterflow to break away from the torpedo shell. At this point, cavitation will take place on the torpedo body in the same way as on the propellers of slower torpedoes at lower velocity.

Cavitation caused by the torpedo body will present serious control problems; depth and steering rudders will be acting in an unstable flow pattern, caused by cavitation bubbles forming and collapsing. Alternate methods of control, such as jet vanes or controlled jet streams, will be necessary to direct the very-high-speed torpedo.

As the ranges of detection and location equipments are extended beyond their present capabilities, greater weapon velocities will be needed. Time of flight must be kept sufficiently short to insure getting the weapon within effective radius of the target.

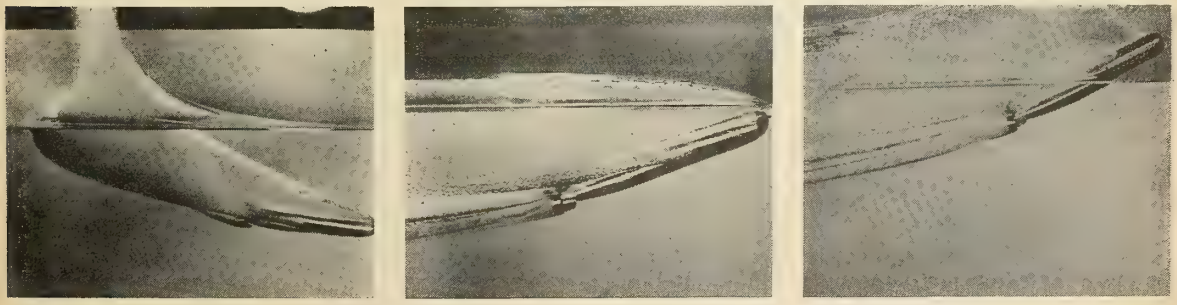
It may prove to be impracticable to design reliable underwater-to-underwater missiles with enough speed to reach extreme ranges in short enough time; thus, air-borne rockets may be the only feasible means of attaining the exceedingly high speed required.

(Ed. Note: This concept of the underwater-air-to-underwater missile is believed to be the subject of a development contract recently placed with Convair's Missile Division. Ideally, this missile would fit the torpedo tubes of current, conventional submarines and have a range of about 100 miles. This has been referred to as a Submarine Launched Inertial Missile—SLIM.)

Increased weapon range will give rise also to a requirement for new techniques to maintain terminal accuracy. One method of accomplishing this is to incorporate some type of remote guidance in the system.

It is feasible to adapt beam-rider guidance, similar to that used in anti-aircraft guided missiles, to underwater weapons. This will increase the probability of bringing the torpedo to within lethal range of the target at maximum range. Another possible means of increasing the kill probability at long range is to increase the lethal radius of the torpedo warhead. An atomic warhead could fulfill this requirement.

Recent technological advances—nuclear power, missile development, advanced hydrodynamics — have been advantageous to the submarine from the standpoint of both offensive and defensive power. A large expanse of rapid progress lies in the future.★



. . . due to uneven pressures to porpoise out of the water and off course.

Russia's Answer to Our SAC Bases

Development Of IRBM-launching Submarines Permits Soviet To Lag Behind In ICBM Work

by Anthony Vandyk

THE SOVIET NAVY's submarine fleet represents to Russia what the U.S. Air Force's Strategic Air Command represents to the U.S. SAC bases ring the Soviet Union. No major target in Russia is out of range of the USAF's B-52s.

For the Russians, however, no overseas bases are available. Even if the Red Air Force could obtain the use of bases in such countries where a strategic attack on the U.S. could be mounted, there is little indication that the bomber aircraft currently operated by the Russians would be suitable for use from such facilities. The Russians have not developed flight refueling anything like to the the extent that the USAF has pushed the technique. It is known that tests are being run for flight refueling the *Badger* (B-47 equivalent), but best intelligence information indicates that the big *Bison* (likened to the B-52) is not equipped for refueling in the air. The big 400,000 lb. turboprop *Baer* is likewise not equipped for flight refueling.

Without air bases and suitable flight refueling facilities for their modern bomber aircraft, the Russians would be in bad shape were it not for their submarine fleet. All evidence indicates that the Soviet submarines are in every way as efficient for Russia as SAC is for the U.S. The Russians have inherited all of Germany's know-how in the field of underwater warfare. The Red Navy took over most of what was left of Germany's World War II submarine fleet and certain construction facilities for underwater vessels.

In particular the Russians carried on development of the W-class long range submarine. The W-class submarine has a snorkel for submerged operation and combination diesel-electric powerplant and is a long-range ship.

The Russians also took over from the Germans underwater launching systems for guided missiles. There is evidence that much of the Red submarine fleet is fully equipped to launch IRBMs from underwater.

The Russian submarine fleet is currently in operational status. It does not remain in Soviet-dominated waters but sails to distant points in readiness for eventual operation.

Last month Senator Styles Bridges (R-N.H.) and m/r Managing Editor Erik Bergaust reported that a dozen submarines had been spotted off Cape Canaveral, Florida, where the U.S. are testing long-range missiles. "The story was not substantiated but we do know that the Russians spare no effort to



Two methods for launching underwater solid propellant rockets studied in this country are the tube-launching principle and vertical launching through the conning tower. Latter method might be employed for the Polaris. Both methods have been considered by the Russians.

learn what we are doing," Bridges stated then.

Other Russian submarines have been sighted near Japan, Newfoundland, and the Bahamas. The U.S. Navy does not comment on these reports but it is known that a large part of its current pre-occupation centers around the threat of the Red submarine fleet.

In the 12 years that the Russians have been working on the development of the German W-class submarine substantial progress has been made in several areas. Speed has been increased and range has been improved. But the most important development is the perfection of techniques for launching missiles from the submarines. It is estimated that every Russian submarine now under construction—production is at the rate of almost one a week—is equipped to launch an IRBM (FBM). The Russian submarine fleet in operation today includes between 400 and 800 vessels. Many of these are early models which are not equipped with missile launching facilities but probably at least a quarter of the fleet is comprised of modern types fully equipped for launching the IRBMs.

Though there's little reliable information as to the state of Russia's submarine missile art, they had a basis to start from 12 years ago—two methods for underwater launching worked out by the Germans but never put into actual operation. As reported previously in m/r, in one case small solid-propellant 21 cm *Borsig* rockets were mounted in external racks on the submarine's deck. These could be fired from under water by controls mounted within the submarine. This weapon system now is believed to have been developed to perfection by the Soviets. With this missile system the Red submarine fleet forms the greatest single threat to United States military security.

Even though U.S. anti-submarine warfare has reached a high state of effectiveness, it's still far from 100%. And with small-but-powerful nuclear warheads a reality, even 20% of Russia's submarine fleet launching even primitive missiles against our coastal cities could cause severe damage.

It is interesting to note that the Russians put great emphasis and faith in any weapon system developed by the Germans. In terms of missile systems, all major German concepts seem to have been adopted and accepted fully by the communists, such as the V-2, the *Reintochter,* the *Borsig* solid-propellant sub missiles, as well as the container-hauled V-2s.

While the Russians had great faith in the Germans and their missile technology and capability, and while several German scientists have enjoyed high privileges in the Soviet since the last World War, indications are the Russians are getting tired of playing with German post-war hardware. They have activated several all-Russian missile programs, and there is no reason to doubt that an all-out submarine-missile program is heading the list.

In addition to submarines, the Soviet Navy has a number of surface vessels equipped as missile ships, but these are of relatively minor importance since they can be easily detected. The submarine poses a very different problem, particularly when equipped with underwater missile launching facilities. It is a very difficult target to hit. Certainly the Soviet submarine threat to the U.S. is every bit as serious as anything that has faced the nation. ★



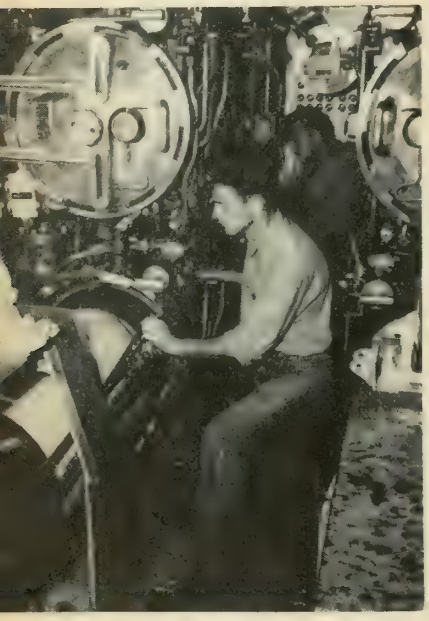
While the Soviet is completely surrounded by our SAC bases, we are faced with the problem of being surrounded by their missile-launching submarines. The latter, of course, are less vulnerable; furthermore, maintaining SAC bases involves close negotiations with our allies.



Liquid propellant submarine missile can be carried to the surface in torpedo-type container launched through large tubes in submarine's hull.

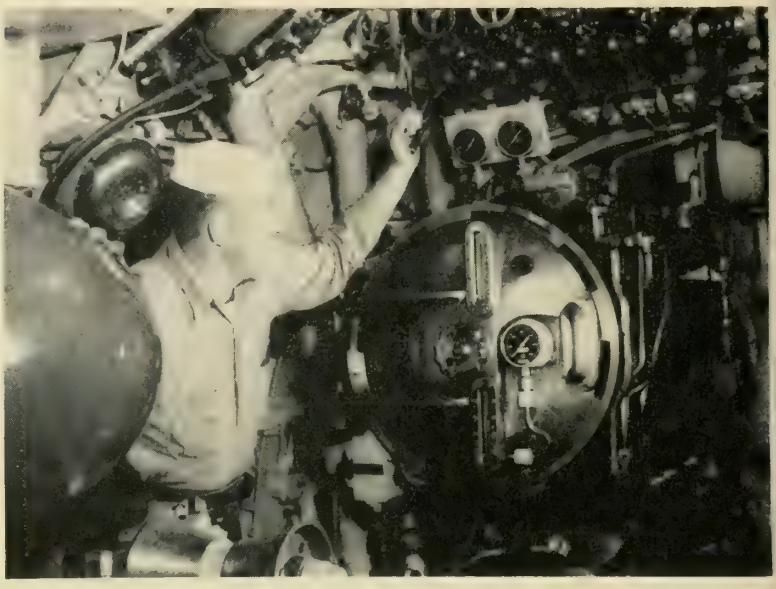
and Off She Goes . . .







Crew on board USS Archer Fish is taking on torpedo for practise exercises. 21-inch diameter electric torpedoes of this type are acoustic. Westinghouse Electric Corporation is now working on sophisticated Mark 37 high-speed, long-range torpedo and Clevite Research and Brush Electronics are pushing a Mark 43 torpedo through test and development. Although most modern torpedoes are acoustic, advanced versions may employ wire or other guidance.



Launching of torpedoes is still tricky business and requires precision and coordination on the part of the entire submarine crew. A miss can be dangerous . . .



. . . but a hit can be rewarding. Especially if the target is a huge tanker or an enemy anti-submarine vessel. This picture shows a successful result after several days of chase. Tomorrow's torpedoes will be too fast and too accurate for an enemy ship to do any evasive maneuvering.

Undersea Missiles at Westinghouse

By James M. Beggs and Thomas H. Campbell, Jr.

Westinghouse Ordnance Department

IN AN AGE when ICBM and IRBM are daily conversation pieces, the *torpedo* has been stripped of much of its glamour. Probably none of the early torpedo designers envisioned that the modern airborne family of missiles are but latter day stepchildren of the first true guided missile, the *torpedo*.

What of the future of the *torpedo as a missile* in the A and H bomb era? This question is easily answered by a spin of the globe and a comparison of water vs. land mass. The logistic mission of sea lanes remains and their ready access and control is as vital. Ship types, speed and propulsion may change but, in the final analysis, troops must occupy territory to control it. They, and air bases, must be supplied.

While our Navy experienced 60% duds in torpedo firing during the first year of the war, the Germans had a successful wakeless electric torpedo and the Japanese were operating an internal combustion torpedo of longer range and larger warhead than any in fleet use. The success of these weapons forced the Navy to look for advanced torpedo design on a "crash" basis and to seek greater production capacity than was available in Naval facilities.

In March 1942, a group of Westinghouse engineers with representatives of other major industrial concerns were invited to view the captured German electric torpedo and propose production bids. On the basis of the proposals submitted, Westinghouse was awarded a contract to develop the Mark 18 electric torpedo. Pressure of war operations and the extreme fleet need caused the Navy to place a time limit of 105 days for design and delivery of a prototype model.

The captured German torpedo was turned over to Westinghouse with the intent that a "Chinese copy" be made for American use. This was impossible since parts could not be adopted to standard manufacturing procedure, some functions were not fully understood and the torpedo could not be adapted for launching in the tubes of American submarines.

The Chinese copy idea was set aside and a major design and development project undertaken using captured knowledge as a starting point. Warhead, exercise head, control mechanisms and torpedo gyro were added to the original development contract and still the tight time schedule was maintained.

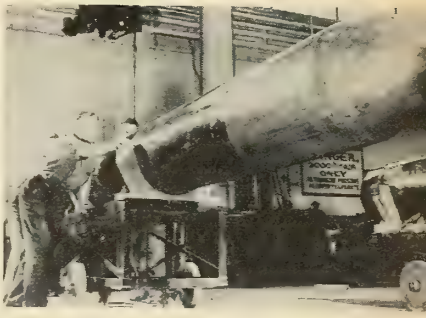
Westinghouse delivered the first model 104 days after receipt of contract and four additional models within 15 days after delivery of the first test vehicle. In conjunction with the development of the torpedo, Westinghouse was ordered to design and develop tooling capable of reaching a maximum production level of 300 units per month, and awarded a production contract. Quantity delivery of the electric torpedos began before the end of 1942 and the Mark 18 weapon was introduced to the fleet in 1943.

When the electric Mark 18 arrived in the submarine force the reception was somewhat less than enthusiastic. Submariners exposed to one device after another which proved faulty, had learned to compensate for some of these faults and were not anxious to be stuck with another dud.

The Mark 18 had slower speed, 28 to 30 knots as compared to 45 knots of the higher powered steam torpedoes and was looked on with disfavor. The first electric torpedoes were taken on war patrol on a voluntary basis. The Mark 18 quickly established a reputation. Submariners became acquainted with the wakeless feature which prevented detection until a hit was secured. the dependable depth performance which allowed shallower depth settings permitting firing at targets previously









The country's largest manufacturer of torpedoes during the last war Westinghouse still maintains leading position in the field. Torpedo output today is classified, but the series of pictures to the right clearly indicate production is going strong. Navy spends approximately $50 million a year for conventional torpedoes.



Enemy shipping sunk by submarine forces during World War II totaled 1,314 ships, greater than the total of all other armed forces. Tomorrow's torpedoes and missiles will be designed to hit surface targets and aircraft as well . . .

neglected, and the simple but reliable contact exploder it carried. The demand for the Mark 18 increased from 30% of torpedoes fired in 1944 to 65% in the last six months of the war.

Parallel with this development, Westinghouse engineers in conjunction with the Navy Laboratories, undertook the design of torpedoes with acoustic as well as electro-dynamic controls. This extensive development program resulted in several different models and culminated with the production of a guided underwater missile, the world's first full-sized, all-electric, acoustically controlled torpedo, utilizing acoustic phenomena to seek out and follow its target until a hit is secured.

These target-seeking torpedoes were put in active use by the submarine force just prior to the close of the war. At that time the enemy's scope of operations was reduced and there was a shortage of good targets for our submarines. However, this self-directed undersea missile sank a total of five Japanese ships and holds the distinction of sinking the last enemy ship in World War II.

The enemy shipping sunk by submarine forces totaled 1,314 ships, greater than the total of all other armed forces. The Westinghouse electric torpedoes introduced at the mid-point when targets were becoming scarce accounted for over 400 ships.

During the interval between V-J Day and the Korean emergency, Westinghouse Ordnance halted production but continued in the field of underwater missile development and the field of sonar application, begun during World War II in cooperation with the U.S. Navy, Bureau of Ordnance. Much was accomplished in the field of miniaturization, control design, and underwater acoustic studies.

During the Korean conflict, Westinghouse Ordnance went into production of torpedoes for fleet use. During the two wars, a total of over 10,000 torpedoes were produced for the Navy.

At the end of the war in Europe, it was discovered that the German submarine force had a torpedo with a system for homing on the propeller noise of ships, giving chase and sinking them, a much more sophisticated system for guidance than that contained in their V-1 and V-2 rockets. It must be assumed that the Russians have access to this undersea missile and that they, as we, have the capability of using this "captured knowledge" to further the art of undersea missile warfare.

Since the self-contained undersea craft presents a grave threat as a launching platform for missiles and harassment to control of the sea lanes, weapons to combat this menace are extremely necessary in the NATO arsenal.

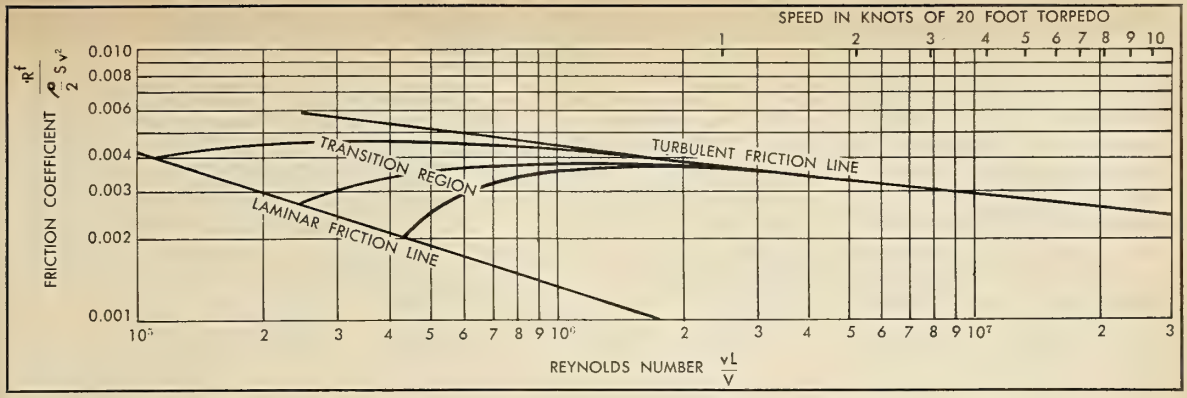
With this Russian capability, what are the problems facing our torpedo designers? The advent of the nuclear powered ships together with improved hull design, make possible higher and higher ship speeds, thus the torpedo of the future must have much higher speed to be effective.

Since the stowage capacity of submarines is limited, torpedoes of the future must be made more reliable and their kill capability must be increased. The history of modern weapons has been one of increasing complexity and the torpedo is no exception. With this complexity has come higher cost.

To justify this expense, our weapons must be increasingly effective and the torpedo of tomorrow must be able to detect, seek, catch and destroy with high probability of success any enemy target, surface or submerged, which ventures into open water.

Westinghouse Ordnance Department which was active in mine development and production during World War II as well as development and production of underwater missiles is continuing to maintain its leadership in the field of underwater ordnance. The company maintains as part of the Westinghouse Baltimore Defense Divisions, complete facilities for the development and manufacture of underwater missiles. This group of development engineers brings the skill and experience of acoustic, electrical, mechanical, electronic and hydrodynamic engineers to bear on the problems involved in developing for the Navy the newest type of underwater missile systems.

Since World War II through Navy-and-Westinghouse-sponsored research and development this group has developed and proven many of the latest concepts in the undersea missile field involving improved performance, speeds, accuracy and deadlines to keep our submarine force equipped to perform their mission in control of the sea lanes and carrying the combat action to the aggressor's waters.★



Beneath the Waves

By Robert Taggart
Reed Research, Inc.

WITH THE ADVENT of the true submersible—atomic submarines that can cruise at high underwater speeds for weeks on end—and with the growing practical knowledge of guided missiles of all types, the oceans assume a new strategic significance. This is why missile-makers now take another, different look at the fish and at birds like the diving petrel and loon.

The basic prototype for an underwater missile is the torpedo which has a long history dating back more than two centuries.

Perhaps the greatest technological change since World War II which affects torpedo design requirements is the complete revision in the concept of submarine warfare. The submarine was primarily a surface vessel which could submerge, when necessary, to stalk a target or to evade avenging anti-submarine vessels. Today, with the advent of nuclear power and other closed-cycle propulsion plants, the submarine is a true submersible.

This imposes a third dimension on torpedo design requirements. With the target free to evade vertically as well as horizontally, the missile must be able to follow these evolutions and strike home with deadly accuracy.

Thus it can be seen that the requirements for the underwater missile of today and of the future are altered drastically from those of the torpedo of World War II. It must attain high speed with a minimum of perhaps 60 knots. It must be silent both to avoid detection and to prevent acoustic interference with its guidance system. It must be capable of operation in three dimensions and of submerging to the maximum operating depths of submarines. The greater its range the more effective it will be.

First consider the speed requirement. Although the speeds of airborne and underwater missiles differ radically there are some similarities. In airborne missiles the sound barrier had to be overcome and now the thermal barrier presents a formidable problem. In underwater missiles similar barriers exist. The first is the turbulence barrier which has long been understood from the standpoint of practical underwater vehicle design.

The principal form of resistance to the motion of underwater bodies is frictional resistance. The amount of this resistance is a function of the surface area of the body and its speed. It is usual to plot this resistance-speed relationship on a non-dimensional basis with the resistance coefficient as the ordinate and Reynolds Number as the abscissa as shown in Figure 1. The resistance coefficient is a function of the frictional resistance, the density of the medium, the surface area, and the speed. The Reynolds Number is a function of the speed, the length of the body, and the kinematic viscosity of the medium.

The curve in the lower left of Figure 1 is the laminar line representing the resistance due to laminar flow over the body. As speeds are increased a transition takes place until a turbulent flow exists along the length of the body. As can be seen the resistance in turbulent flow greatly exceeds that in laminar flow and it can be noted that the transition from laminar to turbulent flow takes place at relatively low speeds. Assuming smooth underwater body 20 feet in length with a surface area of 100 square feet the typical frictional thrust versus speed curves are plotted in Figure 3. It is also obvious that if the body could remain in laminar flow throughout its speed range the



Shipjack, the first operational submarine using revolutionary Albacore hull.

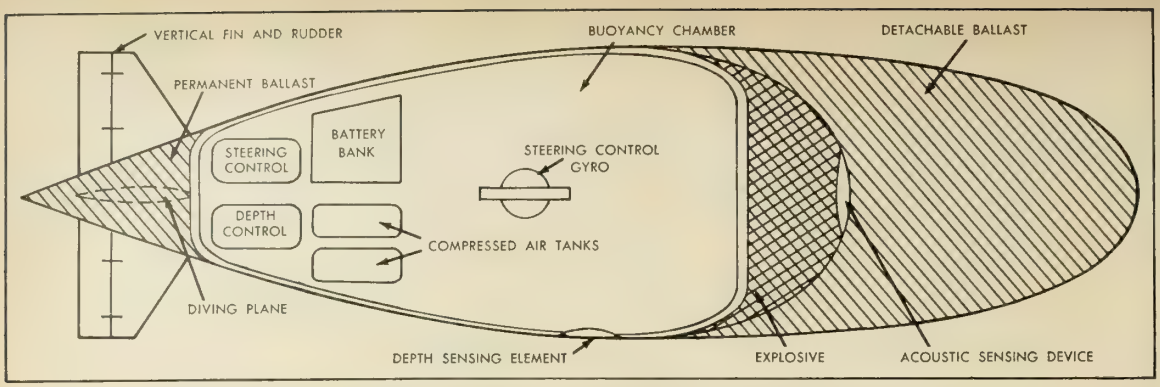


Figure 2. Drawing of possible propulsionless underwater Buoyant Ballistic Inertial Missile—BBIM.

thrust required for propulsion would be greatly lowered.

The cavitation phenomenon presents a more formidable barrier to high underwater missile speeds. As the velocity around a body or a propulsion system increases, the pressure drops. When this pressure becomes less than the vapor pressure of the water, air is pulled out of solution and bubbles are formed. These bubbles have many deleterious effects. They lower the density of the medium to such an extent that the propulsion device drastically loses efficiency thus limiting the top speed at which a missile can travel. The collapse of the bubbles as they enter higher pressure regions takes place with explosive force sufficient to erode away a propeller or control surface in a very short time. This bubble collapse is also a source of very high noise levels which render the missile easily detectable and interfere with its own acoustic guidance.

High underwater speed calls for a form design which varies somewhat from the conventional torpedo body. The total resistance of a submerged body consists of frictional resistance, roughness resistance, and form drag. The frictional resistance is a function of the wetted surface and the speed as shown in Figure 1. Roughness resistance is a function of the type of surface finish which is applied to the body. For a smooth, clean surface the roughness resistance is zero. For the average ship surface a constant addition of 0.0004 to the frictional resistance coefficient gives a resonably accurate estimate. For a well constructed and finished torpedo body an addition of 0.0002 is a fair average.

Form drag, for a well-designed underwater body, is a function of the wetted surface and the diameter-to-length ratio. As a general rule this resistance can be taken as one-half the product of the frictional resistance and the diameter-to-length ratio.

Because the wetted surface is such an important factor in high speed underwater form design it would appear desirable to contain the required volume within a form having a minimum wetted surface. The geometrical shape having the minimum wetted surface to volume ratio is a sphere. Yet if a sphere were used the separation of flow from the afterbody would be such as to make the form drag excessive.

For this reason it is necessary to use a more gradual curvature in the body profile but the symmetry around the axis is retained to form a body of revolution. The final form of a high speed underwater body usually has a blunt nose bordering on a hemisphere. The sections gradually increase in diameter to a point at about one-third the length from the nose and then taper gradually downward to a point, or small radius hemisphere, at the tail. Forms with diameter-to-length ratios on the order of 0.14 evidence the least total resistance for a body of practical dimensions.

There are methods by which the speed at which cavitation occurs can be increased. Since cavitation is a function of pressure, the deeper a missile operates, the less will be the possibility of its propeller cavitating. There are also some hydrodynamic tricks by which the pressure surrounding a propeller can be increased.

One of these tricks is to enforce a lower velocity upon the water as it passes through the propeller. Due to the theorem expressed by Bernoulli, as the velocity decreases, the pressure increases. This can be accomplished by the ducted propeller or pump jet.

Although this design serves to delay cavitation it also enforces an efficiency loss. The interior and exterior surfaces of the duct create an additional wetted surface which adds to the frictional resistance and to the pressure drag. Propulsive efficiency, which is in part a function of the diameter of the jet stream, is also reduced. The overall loss in propulsive efficiency due to these factors is often prohibitive. Various adaptations of this principle, such as the hydroturboprop and the hydroturbojet face the same limitations.

The next logical consideration might be rocket propulsion. Rocket systems have been outstandingly successful in airborne missiles, and hence they would appear to have possible application to the propulsion of underwater missiles. Liquid propellants can probably be ruled out because of the difficulties of handling fuel and oxygen aboard ship. Although storage and transfer systems for these lethal liquids have been worked out, they are extremely undesirable and would not be tolerated unless the justification for their use were overwhelming. Solid propellants do, however, present a distinct possibility for underwater use. In fact weapons already developed employ this means of propulsion in the water. Yet there are many shortcomings to underwater rocket propulsion which should not be overlooked.

Due to the reaction principle, rocket propulsion eliminates the cavitation problem insofar as propulsive efficiency of the missile is concerned. But due to the high velocity of the jet stream relative to the surrounding water, cavitation further aft in the stream is bound to occur which will be a source of excessive noise.

Rocket propulsion is also inefficient from both the propulsion and the resistance standpoint. The efficiency of a rocket propulsion system is a function of the relative velocity of the jet blast and the missile. Since the speed of the missile in water is low compared with its speed in air, the efficiency of the propulsion system is low. The propulsive efficiency is also a function of jet diameter but as the diameter of the afterbody of an underwater missile in-

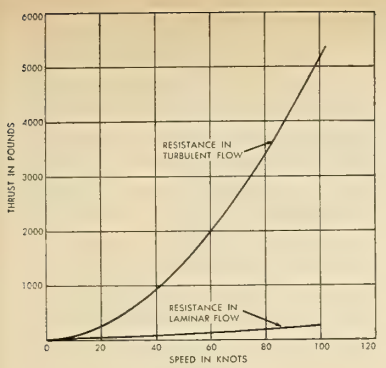


Figure. 3.

creases, so does its resistance.

Thus, although it appears that rocket propulsion with solid propellants may be a partial solution to the underwater missile problem, a number of difficulties remain to be overcome.

Smaller fish such as the swordfish are said to attain speeds in excess of thirty miles an hour. All slender game fish such as the marlin, wahoo, and dolphin are credited with high speed. The 1946-1947 British Scientific Expedition to the Antarctic Whaling Ground made what are considered to be reliable measurements on the speed of whales. Even a lumbering 120 ton, 90 foot monster can attain a speed of 20 knots for a short burst of about 20 minutes duration, and can maintain a speed of 14.5 knots for two hours or longer.

The great maneuverability of the fish appears to lie in his ability to contort his body at will in a manner best adapted to the desired maneuver. This ability is accentuated by the fact that his propulsion and maneuvering mechanisms are integrally related and his full thrust can be directed along the line of the maneuver to be effected. His maneuverability seems also to depend upon size, the whale being probably the least maneuverable of all fish. Yet even the whale can dive and turn with an ease yet unattained by man-made under-water craft.

In studying the propulsion of fish it appears that phenomenal results are achieved in translating muscular energy into propulsive force. One plausible explanation of this phenomenon is that fish actually operate in laminar flow in spite of operation at Reynolds Numbers at which turbulent flow would be expected. Studies on coatings and pliable materials are now being made in an attempt to duplicate this characteristic which has so great a potential value if it can be realized.

The propulsive machinery of fish, being primarily muscle, is silent. His propulsion device, the undulation of body and tail, also appears to be surprisingly noiseless. Studies conducted by the Woods Hole Oceanographic Institute have shown that high speed starts and stops and sharp maneuvering of porpoises produce no apparent cavitation. Indications are that large fish can move at top speed without producing any detectable cavitation or turbulence noises.

Another possible solution to the propulsion problems of high speed underwater missiles is the elimination of propulsion systems entirely. Two forces are available to an underwater missile which may be used to move it through the water—gravity and buoyancy.

One concept of a missile employing these forces is shown in Figure 5. A heavy, detachable ballast weight forms the nose cone. When this cone is in place the missile is excessively heavy in the water. Upon release from a surface ship, aircraft, or submarine, it would drop straight for the bottom reaching a terminal velocity which would be determined by its waterborne weight and its resistance. Control of the diving planes could convert this vertical motion into a glide path at an angle of perhaps as little as 30 degrees with the horizontal. At the greatest depth available the nose cone could be released at which point the missile would become buoyant. It would then rise reaching a terminal velocity determined by the buoyancy and the resistance of the new and smaller form. Again diving planes could be controlled to force the missile into a glide path leading it away from the launching vessel and toward the target.

A gyroscope is provided for directional control and a pressure sensing diaphragm is included to determine the release point of the weighted nose cone. In the nose of the buoyant body an acoustic sensing device is shown which could be used to control steering and diving planes to direct the missile to the target.

The potential of such a missile can best be shown by estimating the performance of a hypothetical design. Using the general configuration of the missile shown in Figure 5 with a length of 18 feet and a diameter of 4 feet, the displacement would be on the order of 9000 pounds. If the nose ballast were a solid steel casting its weight would be about 15,000 pounds. Assuming the weight of the structure and warhead to be 2000 pounds the excess weight would be 8000 pounds. In the dropping phase this missile would reach a terminal velocity on the order of 70 knots in a vertical direction. At a 30 degree glide angle this speed would drop to about 30 knots.

After release of the nose ballast the reserve buoyancy would be about 7000 pounds. During the rising phase of its trajectory the missile would achieve a terminal velocity of about 25 knots on a 30 degree glide angle increasing to 60 knots on a direct vertical rise. A typical trajectory is shown in Figure 4.

This type of missile would be relatively quiet and would be inexpensive. Cavitation would not be a problem. It would be limited in range and in maneuvering flexibility. Its greatest value would be realized in water of great depth which is the controlling factor on range.

Missiles with undulating bodies and underwater ballistic missiles offer interesting possibilities and some food for thought. They are probably not a complete solution for the ultimate in underwater missiles. In fact their deficiencies in this respect have been pointed out. It is quite possible, however, that the fundamental principles upon which they are based may serve in combination with other propulsion schemes to finally evolve a missile which satisfies all requirements. ★

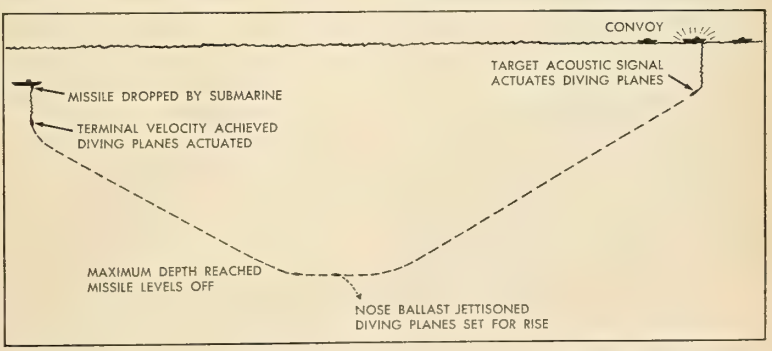


Figure 4. Diagram shows possible trajectory of proposed Buoyant Ballistic Inertial Missile—BBIM—a short-to-medium range missile traveling in absolute silence and not requiring any propulsion system whatsoever. This missile is not an active project but is described to illustrate some of the wholly new approaches possible in water. A variation on this concept using gas cylinders and buoyancy tanks might conceivably be used to transport an IRBM missile across the ocean for launching at the land mass of Europe. By alternately flooding and blasting out tanks it would travel sine wave course—up and down limited only by gas cylinder capacity.

TOMORROW'S TORPEDO

Future underwater torpedo development faces a long hassle with one of the most stubborn elements scientists could encounter—seawater.

This stubbornness is especially evident in guidance and propulsion.

Traditionally the torpedo is preguided. Before launching, its course has been established internally through gyroscopic stabilization and guidance mechanisms programmed for a given pattern.

But in this age of high speed and high maneuverability, the torpedo must now cope with rapidly changing conditions after it is fired.

This means the torpedo must carry its own capability.

Three possible means of detection are: acoustic, radio frequency and infra-red techniques.

Transmissibility of infra-red in seawater is practically nil. At this time there appears little chance for successful use of this part of the spectrum for torpedo guidance.

Underwater radio-ranging offers little hope for underwater detection at any of the frequencies that might be practical for torpedo use.

A good example is the very low frequency communication system used by the Navy for keeping in touch with its submarines around the world (even those that are submerged), which transmits on about 10,000-15,000 cycles. Its antennas cover an area measured in miles, and power output is in megawatts.

The acoustic method of detection seems to have won out for currently operational torpedos. A Westinghouse torpedo on display recently had a rubber diaphragm in its nose.

It is believed an acoustical system is carried by this new torpedo for detection of its target. Whether the device uses sound generated by the target or reflections of sound generated by the torpedo and reflected off the target is not known.

The World War II technique, turning off all noise generating equipment in order to escape detection, would do no good against a torpedo with noise generating equipment.

The need of torpedoes as three-dimensional weapons complicates acoustical sensing problems. Advent of the atomic submarine, and the concept of submarine-launched intermediate range ballistic missiles, means torpedoes must find and destroy the launching submarines.

For this reason depth must be added to operational capabilities.

This restricts the various detection methods to be considered.

Even now, with acoustical guidance, sea water does not present a medium of uniform transmissibility to sound.

Temperature changes rapidly from point to point, and so does the pressure. To these variations can be added other spurious signals reflected from objects other than the target, such as the ocean bottom or schools of fish.

One of the most urgent needs for future torpedoes is the ability to predict future position target.

This need is similar to problems encountered in firing non-detection types of rocket weapons against other aircraft. The speed of both the launching vehicle and the target vehicle must be known and the information used to calculate a collision course.

Submerged speed of the new atomic submarines has not been disclosed. However, they are believed to be of such a high velocity that new types of torpedo detection and prediction equipment must be developed to cope with the problem.

The first electrically driven torpedoes were used by the Germans during World War II. They had the prime advantage of leaving less of a tell-tale wake than bubble-producing steam motors.

Present day torpedoes are electrically powered by motors little larger than ordinary five horsepower motors. However, they deliver "many, many times five horsepower."

As the torpedoes are planned for use at lower and lower depths, the pressure problem mounts. Hull strength becomes a paramount concern of any new torpedo design.

From purely a propulsion point of view significant successes have been achieved in research and development work with more sophisticated types of propulsion. In many cases these parallel those used for airborne and space-bound missiles—ramjets and pure rockets. Speeds triple those of World War II torpedoes have been achieved in special full-scale test tanks.

The main draw-back has been and remains that these missiles are extremely noisy. Also, unlike the electric torpedo, many leave an all-too-obvious bubble wake. This gives the target two methods of detecting the attack missile—visual and acoustic.

In addition, there is still no known hydroform that can travel at 100-knot speeds without cavitating. This phenomenon is a major source of noise in itself. However, work now underway to develop methods for providing boundary layer control for subsurface vehicles, if successful, will revolutionize the basic concepts of undersea warfare.

One view of the torpedo of tomorrow might be as follows: Its body will be made of magnesium, plated to provide a smooth high gloss finish. Its detection and homing gear will be acoustic; will have a range of well over 100 miles if necessary; and will concentrate in the ultra-low frequency ranges. Its speed may be anywhere from 150 knots upwards. Its propulsion system will consist of a hydroduct (ramjet) whose "combustion" products are either heavier-than-water solids or solubles, thus leaving no visible wake. Hydrodynamically, it will be near-perfect, providing means of pressure equalization (boundary layer control), perhaps with ducts to feed in or draw off water as necessary. Its range may be anywhere from 10 to several hundred miles. Its warhead will be either nuclear or with conventional explosives.

Another factor in torpedo design is the need for operation more than once. A torpedo is fired only once "in anger" but might be fired a number of times for tests.

A one-shot electric motor might be designed for a very high efficiency if it were to be used just once. But the motors used in torpedos must be capable of both repeated use and high efficiency.

Thus far most torpedo research and development has been done by government laboratories. The product of this work was then handed to industry for integration in a weapon.

With the increased need for torpedoes for use against missile-launching-submarines and perhaps an anti-torpedo torpedo, the systems engineering approach becomes more necessary, as it has in atmospheric and space missile designs.

At least one company plans development of torpedoes on a systems engineering basis.

UNDERWATER PROPULSION

Engineering Horsepower to Velvet Hooves

IN WORLD WAR II, the submarine revealed its full potential for destruction, and among the steps taken to cope with the menace to our shipping was the application of the then newly developed techniques of sonar to electronically control the steering of a small electrically-propelled torpedo. This passive-acoustic homing torpedo was perhaps the first "guided missile" in the sense that we know it today.

But spectacular advances in underseas warfare capability have occurred with the advent of nuclear-propelled submarines, and the simple battery-propelled torpedo of the immediate post-war years is useless against such submarines, both from the speed and deep-diving standpoints. Modern weapons are needed for the anti-submarine defense of future years. Although some refinements are possible in both batteries and electric motors, it is obvious, from the energy requirements involved, that some kind of thermal propulsion will be needed in torpedoes capable of attacking, say, a submarine like the Nautilus.

The problems of thermally propelled, high-speed, deep-diving anti-submarine missiles are yet to be solved completely. The powerplant developments have much in common with airborne guided missile technology, but are distinctly different because of the fact that the torpedo is "flying" in a surrounding of water rather than air or space. Some of the special problems of anti-submarine torpedo power-plants are structural integrity, acoustic silence, the effects of deep operation on power-plant performance, and the utilization of "exotic" fuels.

For this comprehensive roundup on progress in modern underwater missile propulsion systems, m/r is indebted to the U.S. Navy Bureau of Ordnance which performed in accordance with the highest traditions of the Naval service. This article is a combination of two received—one by Jack W. Hoyt, Naval Ordnance Test Station, Pasadena; and one by G. G. Gould, J. F. Brady, S. Wolf and R. M. Dunlap, Naval Underwater Ordnance Station, Newport, R. I.

In general, all torpedo propulsion systems consist of an energy source, a feed system, a device for converting the stored energy into torque and a device for converting torque into thrust. For extremely high speed vehicles, the conversion of stored energy into thrust may be accomplished directly in a reaction chamber-nozzle assembly.

In 1903, the first turbine-driven torpedo was produced by the Bliss-Leavitt Company from 1905 through World War II, all U.S. thermal powered torpedoes have used turbines as prime movers.

Electric torpedoes started with the Foster torpedo in 1872. This torpedo, as well as the more successful Sims-Edison in 1877, was controlled and powered from a shore station by means of a trailing wire. For want of a satisfactory battery, development of electric torpedoes was abandoned in this country. The Germans however, placed them in service in both World Wars.

The characteristics of torpedo energy sources are the same as those for guided missiles with one major exception. For reasons of stealth, the torpedo should have no wake. Its exhaust, if any, should have a predominance of condensable and soluble products.

For certain applications the range and speed requirements of the torpedo are such that a relatively low energy storage capacity is required, which favors battery-motor propulsion. These also have the advantages of no wake and performance independent of depth.

The World War II electric torpedo used a conventional lead-acid battery. Now, Silver cell batteries (Zn-alkali-Ag202) are up to six times lighter and five times smaller than lead-acid batteries for the same output. Primary batteries such as the magnesium sea-water-silver chloride are even lighter and smaller.

For the higher speed, longer range torpedoes, total energy requirements are such that thermal power plants must be used. A wide variation in performance is achievable, depending upon the propellant combination. Because of their relatively high performance





New Bedford shoemaker Wm. Cunningham's rocket powered torpedo was way ahead of its time when, in 1894, he touched it off in the road before his house. The only casualty was a fire in the local butcher's icebox. Unfortunately, it never found its way into the Navy's Arsenal.

and their potentially wakeless exhaust products, hydrogen peroxide-hydrocarbon systems have been widely used.

Use of either carried fresh water diluent or free sea water diluent is necessary in turbine propulsion systems in order to decrease the operating temperatures. The use of sea water, although significantly increasing the performance per unit of carried expendables, poses the serious salt problems.

For reciprocating engine power plants, no diluent is necessary. Copious quantities of sea water are required, however, to cool critical engine parts.

Monopropellants, although attractive from a simplicity point of view, are relatively low in performance and, in general, have a high percentage of non-soluble gases in their exhaust.

For torpedo application, solid propellant systems are attractive because of their simple mechanical construction, minimum number of parts, simplified handling and lack of feed system requirements. As a result of the system simplicity, its reliability should be high. The disadvantages of solid propellants as torpedo energy sources are the large quantity of non-solubles in their exhaust (wake) and their inflexibility in packaging to obtain a desired gas generation rate.

As undersea warfare is largely a matter of listening, it is paramount that a weapon be quiet.

Another requirement for the torpedo propulsion plant is small size and weight, particularly for the aircraft launched torpedoes. Overall weapon system weights are often lower than 400 lbs.

It is the deep-diving requirement that makes the ASW torpedo powerplant problem really unusual.

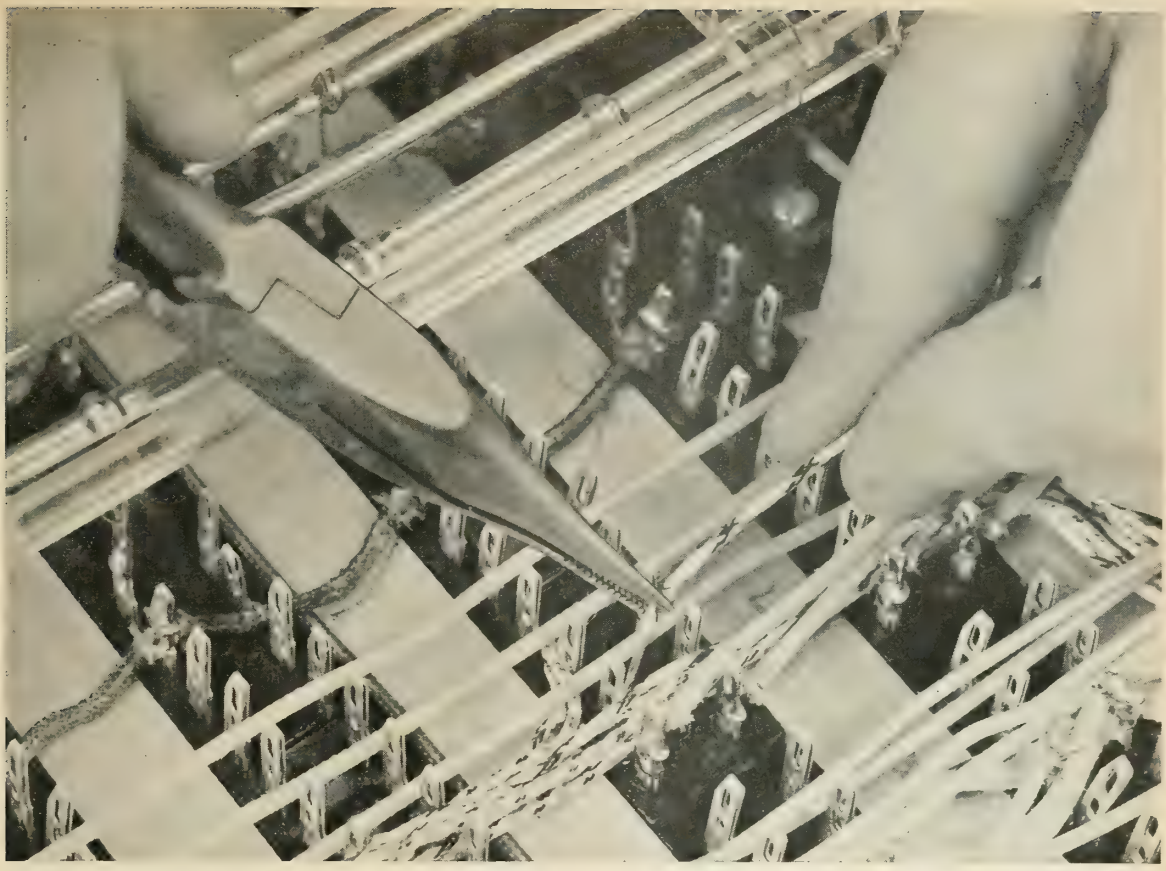
The high back pressure encountered at deep submergence strongly influences the choice of thermal powerplant employed in the missile—should it be a reciprocating engine, or should a turbine drive be used? Actually there appears to be, as in aircraft propulsion, definite regimes in which one or the other method has a weight-volume advantage.

Generally speaking, American practice indicates that in the lower power levels, say under 100 or so horsepower, the engine drive is a more economical thermal system, but above this level, turbine drives are better. Torpedo reciprocating engines operate on essentially a "steam-engine" cycle, which is less affected by back pressure than the simple turbine cycle; this advantage is outweighed by greater powerplant bulk as the power level increases. Torpedo turbines are usually of the partial-admission axial-flow type; the high back pressure penalizes the small power level turbine due to high windage losses. As the power level is increased, this penalty diminishes.

Partial admission means that gases are admitted to only a portion of the periphery of the turbine—while the remaining blading churns relatively stagnant gas. As the back pressure on the



Striking demonstration of the similarity between aerodynamics and hydrodynamics, this model of a Chance Vought F4U was put in water tunnel to study turbulence in high subsonic range.



Memo to control systems manufacturers:

If you've got a really tough cable problem, Rome's cable specialists can solve it

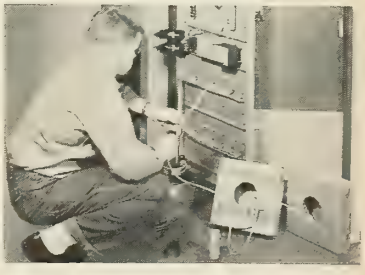
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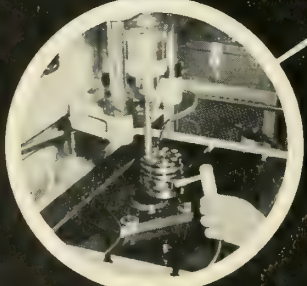
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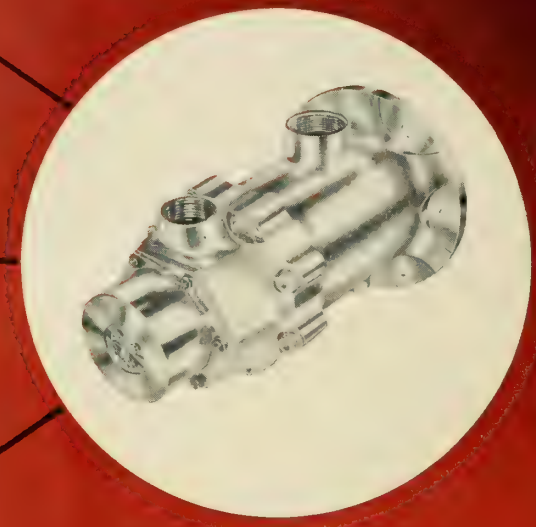
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turbine is increased to, say, the 500 ft. submergence level, the power absorbed in this churning (the so-called "windage loss") becomes appreciable.

The high windage losses of axial-flow torpedo turbines has led to the consideration of tangential-flow machines of the type manufactured by the Terry Steam Turbine Co. These turbines appear to have a windage loss similar to a smooth disk, and although their aerodynamic performance is perhaps less than that achieved by axial-flow units, their shaft output is relatively constant over a considerable range of depths.

Because of their simplicity, reliability, wakelessness, and insensitiveness to depth, electric propulsion systems have always been attractive. Unfortunately, the power-to-weight ratio of such systems has always been low. Design effort, therefore, has been expanded to development of high power-low weight electric motors. An obvious method for improving the power to-weight ratio is to increase motor speed. This necessitates either high speed propellers or a gear reduction.

Unfortunately, experience has shown that either alternative results in higher radiated noise. Counter-rotating electric motors serve to increase power-to-weight ratio without requiring gear reducers. Considerable improvement, noisewise, is obtained thus.

Except for electric drives, the turbine has been the traditional power plant for U.S. torpedoes. Overall prime mover efficiencies of the pure impulse turbine (including gear train losses) of approximately 48% are being obtained, compared with the turbines of jet aircraft and of stationary power plants which obtain 85-92% efficiency. A perhaps more important criterion is the working fluid through-put required per unit of power. Representative values for various types of turbine systems are as follows:

Steam power plant .	7.46 lbs/HP hr
Aircraft turbo prop engines	15.4 lbs/HP hr
Torpedo turbine ...	12.0 lbs/HP hr

Considering the torpedo turbine's compactness, it compares quite favorably.

In brief, the trend in torpedo turbine design is toward higher rotative speeds, more arc of admission, higher inlet temperatures, and improved gas passage design to reduce shock wave problems. Consideration is also being given to multi-stage units to more efficiently handle the high pressure ratios.

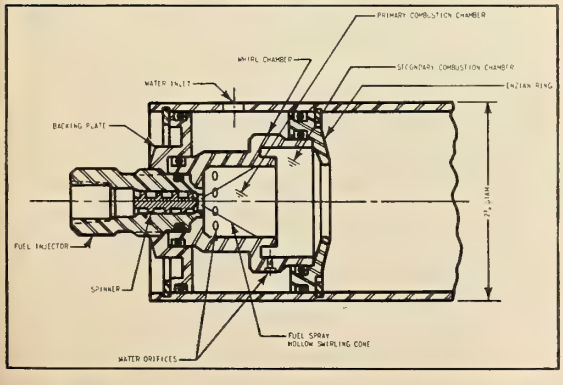
Recent advances in metallurgy, however, allow us to increase speeds to more favorable values. For example, at 1200°F Inconel "X" has a working strength of 74,000 p.s.i. compared to 11,000 p.s.i. for 8630 steel. Thus, at 1200°F Inconel "X" wheels may be run at speeds 2.5 times as fast as wheels made from 8630 steel.

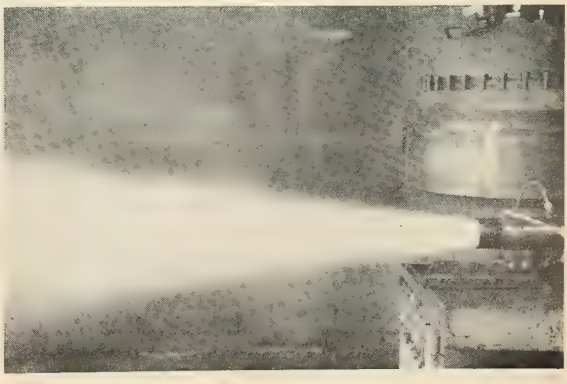
Arc of Admission: To date, torpedo turbines have utilized less than 25 per cent of the available arc of admission. If the entire arc were used, four-to-five times more power would be obtained than is required. To utilize the full arc of admission, without producing tremendous quantities of power, requires reduction in the size of the machine. To maintain a good ratio of wheel to jet speed, the rpm of the machine must be increased. Advances in bearing design now permit running at speeds above 50,000 rpm whereas a few years ago 10,000 rpm was considered high.

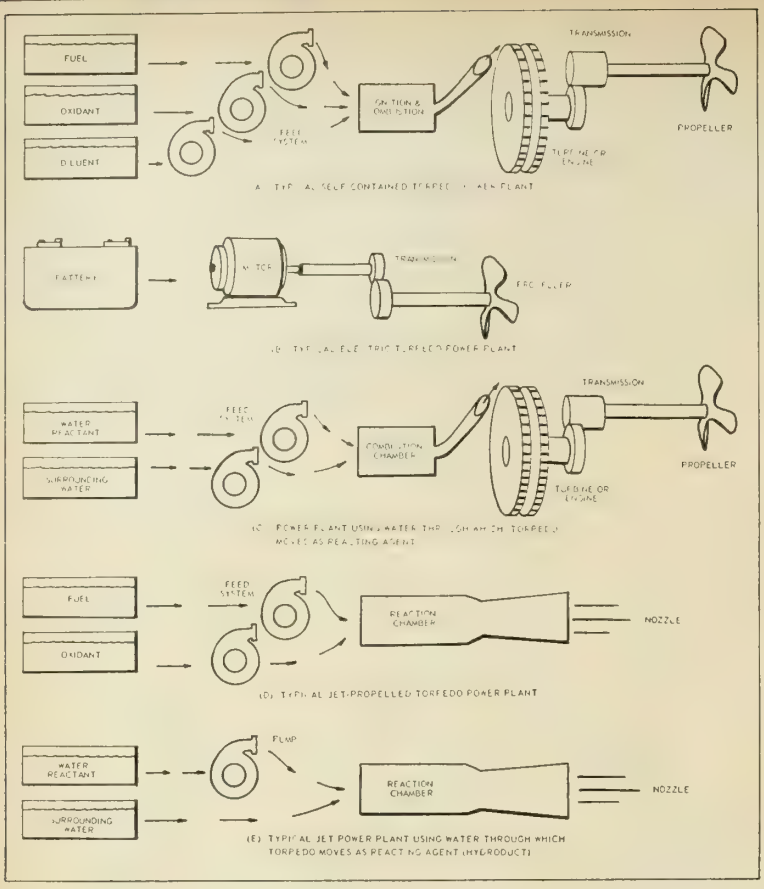
Because of their high efficiency in the lower power output range, their ability to operate without a diluent, and their lack of windage problems, reciprocating engines are competitive with turbines for certain applications.

Early torpedo reciprocating en-

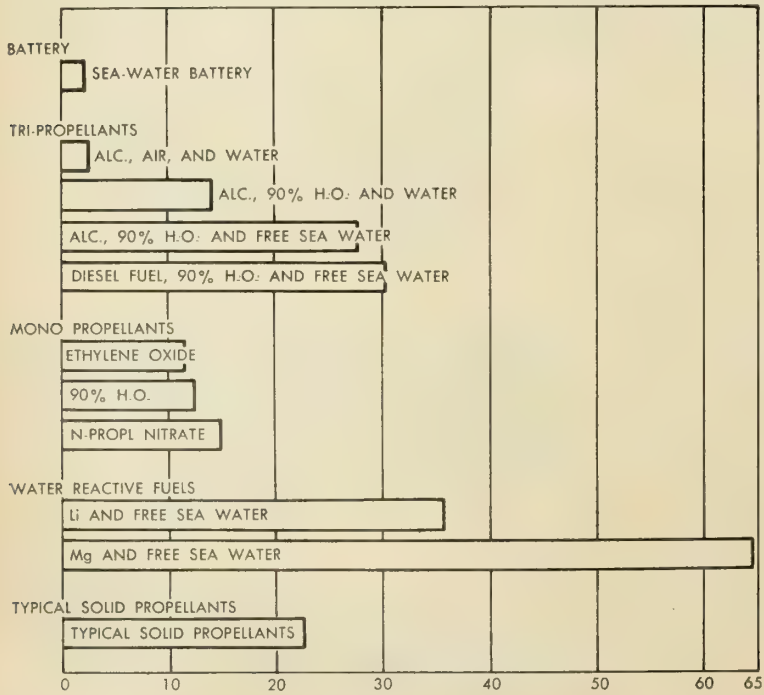
Combustor for torpedo turbine drive resembles rocket motor. To the left is a schematic drawing and to the right the combustor is shown on a static test stand, looking much like a rocket.







Above are the basic layouts of five possible torpedo propulsion systems reading down in the order of their sophistication. Below, their theoretical comparative performances are charted.



gines were similar in most respects to conventional steam engines, running first on compressed air and later with hot gases burned in an external combustion chamber. Air was first used as the oxidant, and more recently, hydrogen peroxide. One version of the engine uses peroxide decomposition products as the oxidant while other experimental engines utilize direct injection of liquid peroxide into the cylinders.

Most torpedo reciprocating engines operate on a two-stroke, modified Brayton cycle. A four-stroke cycle torpedo engine was developed by the Germans during World War II, but not placed into service.

Numerous mechanical engine designs have been made. Three and four cylinder radial, four and eight cylinder "V," horizontal opposed piston, and various barrel-type configurations have been tried.

The major problems still to be solved include valving, cooling, and reliability. Reciprocating engine design still remains more of an art than a science. The solution to most problems must be obtained by "cut and dry" methods as opposed to the refined theoretical work that may be accomplished on other types of prime movers.

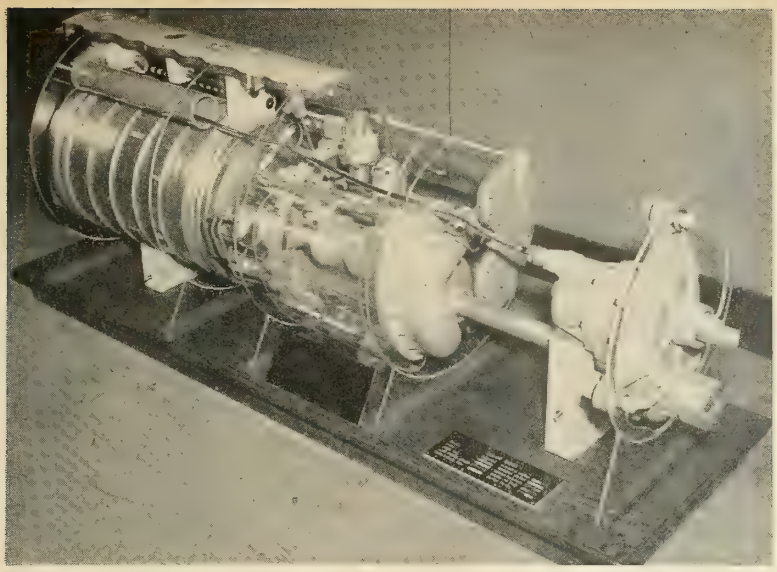
Devices analogous to the aeropulse, the turbojet, and the ramjet are practicable for underwater propulsion. These devices are the hydropulse, the hydroturbojet, and the hydroduct respectively. Use of underwater rockets, although technically feasible, is impractical except for extremely short ranges because of the unfavorable ratio of torpedo-to-jet speed.

Although all the above jet devices are promising for torpedo propulsion, their use will depend upon the requirements of the future.

The power plants described above require extensive testing to ensure that they function reliably under all conditions of operation.

Many of the questions concerning the components respond to conventional test techniques. Some do not. Take for example, simulation of the operation of a gas turbine and combustion system driving a torpedo in 1000 feet of sea water, corresponding to a back pressure of 444 p.s.i. with combustion chamber pressures of perhaps 1800 p.s.i. Containing and controlling these pressures, absorbing the power and extracting the performance data becomes a formidable problem. So does measurement of differential pressures across flow control orifices.

Noise output of torpedoes is measured while the torpedo is running, both captive and free. At the Underwater Ordnance Station in Newport, R. I. is



A modern torpedo reciprocating engine including fuel tank, oxidizer tank, accessories, controls.

what is believed to be the world's largest tank for the measurement of the underwater sound output of a captive torpedo running under full power.

At the Aerojet-General Corp. in California is another unique facility. Here a tank of water in the shape of a ring is equipped with a rotating arm which can carry a full size torpedo at speeds double those of most torpedoes. In this tank the thrusts of novel propulsion systems, employing high velocity jets, can be measured. When the engineer reports that the torpedo is still putting power into the rotating boom at over one hundred knots, history is being made. This tank is equipped with special wave dampeners to effectively still the water for the torpedo as it hurtles through the ring channel time after time.

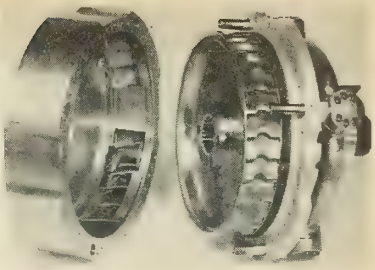
To measure speeds and accelerations of free running torpedoes, the Navy has installed in the bottom of Narragansett Bay, R. I., a grid of hydrophones connected by over one hundred miles of underwater cables. These hydrophones, listening to noise made by the running torpedo, feed banks of recorders and computers to provide reliable witness to the performance of the tin fish as it speeds up the range.

The underwater range can plot, second by second, the position of the torpedo to within a few feet during its run. Sound measurements, well into the ultrasonic range, are recorded to be compared with those made in the anechoic tank.

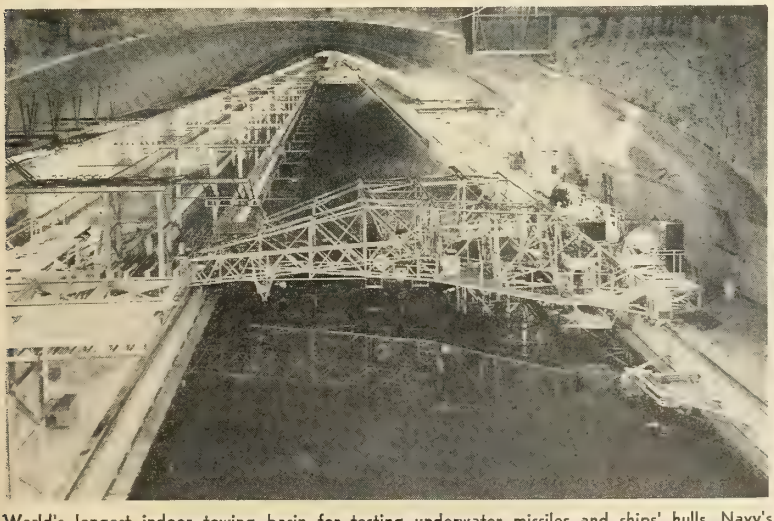
Practical limits are imposed in the design of torpedoes by other considerations than the power plant alone. For example, a running range of 50 miles, with the necessary fuel to go that far, although technically feasible, is operationally unsound. But even assuming a 100 mph torpedo, the time of flight to the target would permit a half hour of evasion on the part of the target ship. Even at shorter ranges, while a 50 mile-per-hour torpedo takes two minutes to go 3000 yards, a 15 knot target can travel 880 yards.

Thus the need points to shorter flight times. This can be achieved in many ways. One obvious means is by increasing the speed, although this has certain limitations. A most significant problem is the horsepower required since this goes up as the cube of the speed. Ultimately, the torpedo could be designed to operate in two mediums —be fired from underwater, emerge and fly most of the way through the air and then return to the water for its final phase of attack.

With atomic submarines a reality, future targets will be capable of much higher sustained speeds. The torpedo of tomorrow is aimed toward defeating the high performance submarine of the future. ★



Tangential-flow turbine is only slightly affected by windage losses at high back pressures. This is type of turbine used with combustor.



World's longest indoor towing basin for testing underwater missiles and ships' hulls, Navy's David Taylor Model Basin has an uninterrupted run of over 3,000 feet and towing speeds up to 60 knots (69.1 mph). So close is test control, two car rails are adjusted to earth's curvature.

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Ready availability and ease of preparation.

Non-corrosive materials and products of combustion.

Shock insensitive under external shock, high temperatures.

Simple and positive ignition with short ignition delay time.

Primary requirements to be considered in the selection of propellants for modern torpedoes.

Underwater Missile Auxiliary Power Units

By William L. Burriss
and Matthew J. Pastell
AiResearch Manufacturing Company



Woosh! Out of the deep blue sea . . . Amazing German submarine rocket experiment was in the mill at end of World War II, but German admiralty refused to develop the system since it was conceived and demonstrated by the Army...

THE GUIDANCE and control of missiles can only be effected through the use of internal power, usually electrical and hydraulic. In most instances this power is not available from the main propulsion engine. It is necessary, therefore, that an auxiliary or secondary power source be provided within the missile.

The use of static power supplies, batteries and precharged hydraulic-pneumatic accumulators has been effective in early operational missiles because such power packages are particularly advantageous for small loads of short duration. However, similar components for increased loads and longer duty cycles of missiles in development and still "on the board," in general, would be excessively large and heavy. Under these conditions, the utilization of "dynamic" energy sources, i.e., a propellant gas-operated prime mover driving a hydraulic pump and electric generator, could effect large savings in space and weight.

Considerable experience has been gained by the missile industry in the use of propellant gas turbines for auxiliary power. Although analysis indicates other prime movers such as displacement type machines to be feasible (perhaps even advantageous), there is little experience in their application.

The most common requirement for an auxiliary power unit (APU) is to provide a-c electrical power. When direct current is required, in almost every case rectification of high frequency a-c power will show a considerable advantage over the use of d-c generators.

The total power level does little to affect the complexity of the unit, but the quality and variations in electrical output are primary considerations in establishing the complexity and reliability of the complete system. Close frequency control over a considerable load range requires a complex speed control system, and close voltage control requires the addition of voltage regulators.

At present, frequency control can be maintained within ± 3 per cent over a 0 to 100 per cent load range, ± 2 per cent over 75 to 100 per cent load range, ± 2 per cent over 50 per cent to 100 per cent load range, and ± 1 per cent at constant load with a fairly simple and reliable speed control. With a more complex system, frequency regulation to within ± 0.20 per cent can be maintained over any desired load range.

Over small electrical load ranges, permanent magnet alternators offer advantages in simplicity and light weight and have sufficient inherent voltage regulation for many applications. Since the output voltage of the conventional permanent magnet machine is not controlled, it will vary in direct proportion to the alternator speed; therefore, the over-all variation in output voltage is the sum of the frequency variation plus the alternator voltage "droop" over the desired load range.

In addition, these are sensitive to power factor so that variation in power factor also increases the over-all voltage range. When the electrical load variation exceeds 70 to 100 per cent, additional alternator mass is required to provide sufficient inherent regulation for proper over-all voltage control (± 5 per cent) or else some type of regulator must be employed.

References:

(a) NACA TN 1807—*Effects of Partial Admission on Performance of a Gas Turbine.*

(b) Stodola, A., Steam and Gas Turbines, Vol. I, McGraw-Hill Book Co., Inc., 1927, pp. 194-202, (Reprinted, Peter Smith, New York, 1945).

(c) Vincent, E. T., *The Theory and Design of Gas Turbines and Jet Engines,* McGraw-Hill Book Co., Inc., 1950. pp. 415-422.

Present trends in missile accessory power units indicate that voltage regulation is generally more critical than frequency regulation and that when electrohydraulic output is required, very large changes in load can be expected. These trends favor the use of alternators with a controllable electromagnetic field which can be adjusted automatically to eliminate the effect of frequency on output voltage and compensate for the normal voltage "droop" when changes in electrical load occur.

A flux-switch alternator with a combination permanent magnet and electromagnetic excitation with the latter supplied by load-current sensing transformers provides good voltage regulation.

Duty cycle and alternator frequency are primary considerations in sizing an alternator for power supply use. High frequency (800 to 10,000 cps) allows high rotational speed with attendant reductions in size and weight. The duty cycle will determine the thermal capacity required of the alternator to avoid overheating, and as a consequence, the weight of materials in the alternator.

External cooling with fuel or by other means can either considerably increase the operating duty cycle or generally reduce the alternator weight for a given duty cycle. An example of how high frequency and short duty cycle (uncooled) can reduce alternator size is a 3-kw, 4800-cps, 48,000-rpm alternator weighing 3 pounds.

On units requiring hydraulic power, the hydraulic system demand is usually such as to require steady-state power at a low level and transient power at a considerably higher level. In selecting the hydraulic components which will best meet the requirements, various hydraulic pump and accumulator combinations must be reviewed to see which combination results in minimum system volume and weight.

The first step in the review is to translate the hydraulic requirements to total volume of hydraulic fluid required as a function of flight time. By comparing the requirements with various hydraulic pump capacities, it is possible to determine the accumulator volume required for any given pump capacity.

The accumulator volume is then plotted as a function of pump capacity. Since the pump capacity determines, to a large extent, the power level of the system, it is also possible to establish propellant volume as a function of pump capacity. By combining accumulator, reservoir, propellant and pump volumes, it is possible to prepare an optimization curve of total hydraulic system volume as a function of pump capacity.

Using this optimization curve and considering secondary effects such as pump heat rejection, control system complexity, and packaging restrictions, a pump-accumulator combination is selected to provide the smallest practicable hydraulic system.

Speed control can in general be achieved by two methods: (1) by the application of external parasitic loads; and (2) by controlling the flow of the turbine working fluid, either as raw fuel or as hot exhaust gases.

Each of the general methods can be applied in either of two ways:

1. Discontinuous—When speed control is being maintained in this fashion, the parasitic load is applied or the working fluid shut off only when the upper speed limit is approached. When the unit has decelerated to the lower permissible speed, the load is removed or flow of the working fluid is initiated. The step-load change characteristic of this method has sometimes led to its being called a "bang-bang" control scheme. Present ethylene oxide auxiliary power units provide speed regulation to about ±2.5 per cent using a "bang-bang" fuel flow control, and solid propellant units have been built to about ±1 per cent.

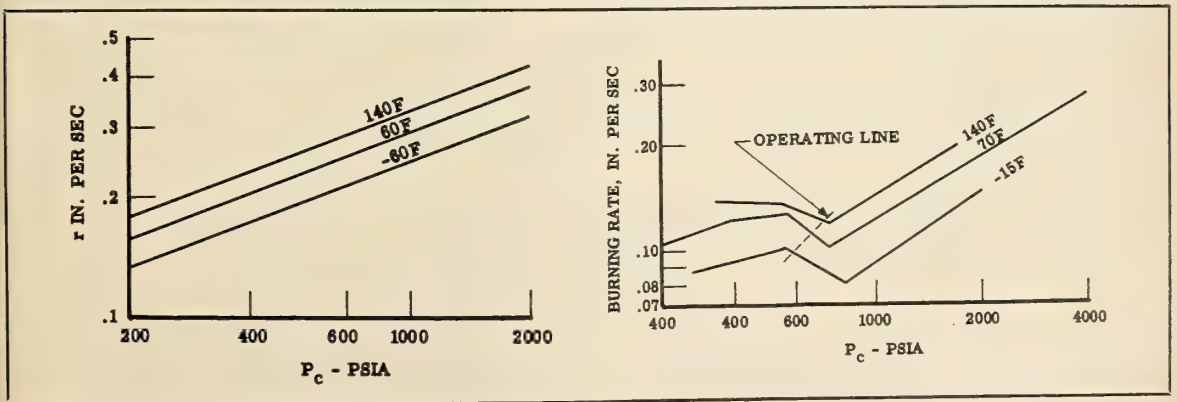
2. Proportional—When speed is controlled in this way, the parasitic load is applied in proportion to speed or the working fluid flow is varied in inverse proportion to speed. Using proportional fuel flow regulation and sophisticated electronic controls, steady-state accuracy to ±0.2 per cent can be attained.

The applicability of a control scheme is dependent upon the type of load changes imposed upon the over-all power unit. Step-load changes, like those encountered when a hydraulic power unit incorporates a hydraulic pump unloading valve, makes close-speed control more difficult and usually requires increasing the complexity of the system.

The ideal isentropic power derived from any turbine can be expressed as $HP_i = W\triangle H$

Where HP_i = ideal power input
W = weight flow of working fluid through the turbine
$\triangle H$ = enthalpy drop per pound of working fluid

Of course, the ideal power is not realized as the result of leakage losses, aerodynamic nozzle and blocking losses, and shaft losses. The shaft losses for a full-admission turbine include bearing losses and disk friction and windage losses. The disc windage losses as shown by References (a) and (b) may be expressed by the following approximate relationship:



Mesa type discontinuity exhibited by doublebase propellants tends to minimize dependence of burning rate on pressure.

$$HP_{df} = K_1 p D^2 V^3$$

where HPdf = disc friction power loss
K_1 = proportionality constant determined by turbine rotor design and clearances
p = fluid mass density
D = rotor diameter
V = rotor peripheral velocity

Since the propellant gas turbines designed for missile auxiliary power unit applications are characterized by relatively low power output (1 to 70 shp), they are usually partial admission machines. Of the major losses that occur, the leakage losses are approximately proportional to the degree of admission, while the windage losses are relatively independent of the degree of admission. For this reason, in order to evaluate turbine performance in an application wherein significant windage losses are expected (as result from the exhaust back pressure in an underwater missile), it is appropriate to define the turbine over-all efficiency as follows:

$$\eta_o = \eta_{ad} \frac{HP_s}{HP_s + HP_{df}}$$

where η_o = over-all turbine efficiency
η_{ad} = turbine adiabatic efficiency
HP_s = shaft power output
HP_{df} = disc friction power loss

Further, it can be seen that the turbine adiabatic efficiency can be expressed as a function of the turbine velocity ratio, U/C (ratio of the effective rotor tip speed to the spouting velocity), shown by Reference (c) to be as follows:

$$\eta_{ad} = K_2 \frac{U}{C} (\text{Cos} \propto - U/C)$$

where K_2 = constant of proportionality determined by turbine design
U = effective rotor tip speed
C = spouting velocity of the working fluid
$\propto$ = absolute gas inlet (to turbine) angle

It can be seen, therefore, that the over-all turbine efficiency may be expressed

$$\eta_o = K_2 \frac{U}{2C} (\text{Cos} \propto - U/C) \frac{HP_s}{HP_s + K_1 P D^2 U^3}$$

This indicates that, while the adiabatic efficiency increases linearly with the turbine tip speed, the windage losses increase as the cube. It further indicates that some sacrifice in the adiabatic efficiency is necessary for optimum over-all performance. For example, a 4.0-inch diameter turbine rotor rotating at 50,000 rpm will have disc friction losses of approximately 1 horsepower at sea level (14.7 psia turbine discharge pressure).

In an underwater missile application at 1000 feet depth with a turbine exhaust pressure of approximately 500 psia, the disc friction losses for the same turbine would be about 30 horsepower.

When compared to the APU output of a nominal 10 hp this leads to an over-all efficiency of one-fourth the adiabatic efficiency. It is clear then that reasonable efficiencies will be difficult to achieve on small output units with a conventional turbine.

Use of a drag turbine or a displacement type machine is indicated for low output (under 50 hp) applications. A drag turbine offers an advantage in such applications since reasonable efficiencies are obtained at very low velocity ratios. This permits use of low shaft and tip speeds where disc friction losses will be low and also offers the possibility of providing direct drive of a generator and hydraulic pump without the conventional gearbox. Analysis also indicates that relatively high efficiencies, in the range of twenty-five to forty per cent, can be obtained from displacement machines operated off propellant gases. However, the displacement machines will find restricted applications until more experience is gained in their use.

The turbine working fluid of an auxiliary power unit is usually the hot decomposition or combustion products of a propellant. Some very small, short duration power units have used high-pressure stored gas, but because of the very low energy content of cold as compared to hot gas, it is seldom employed and is not discussed here.

Solid Propellant and Liquid Monopropellant

The solid propellants offer two great advantages, simplicity and compactness. However, because of the relatively high burning rates of existing solid propellants, and the fact that the entire fuel tank must be stressed for high temperature—high-pressure operation, their use has been limited to units of relatively short duration. Also, once combustion of a solid propellant is initiated, it cannot be readily controlled by external means, so it cannot be started, completely stopped, and restarted as is required by some irregular duty cycles. Solid propellants are essentially constant energy devices which cannot be metered for operation at part load.

The liquid monopropellants allow considerable flexibility in packaging since the required fuel volume conceivably can be contained in a tank of practically any shape. They also have the advantage of being able to be started and stopped as required by controlling fuel flow to the gas generator. The primary disadvantages of the liquid monopropellant system are its relatively high dead weight (for short duration units) and its complexity.

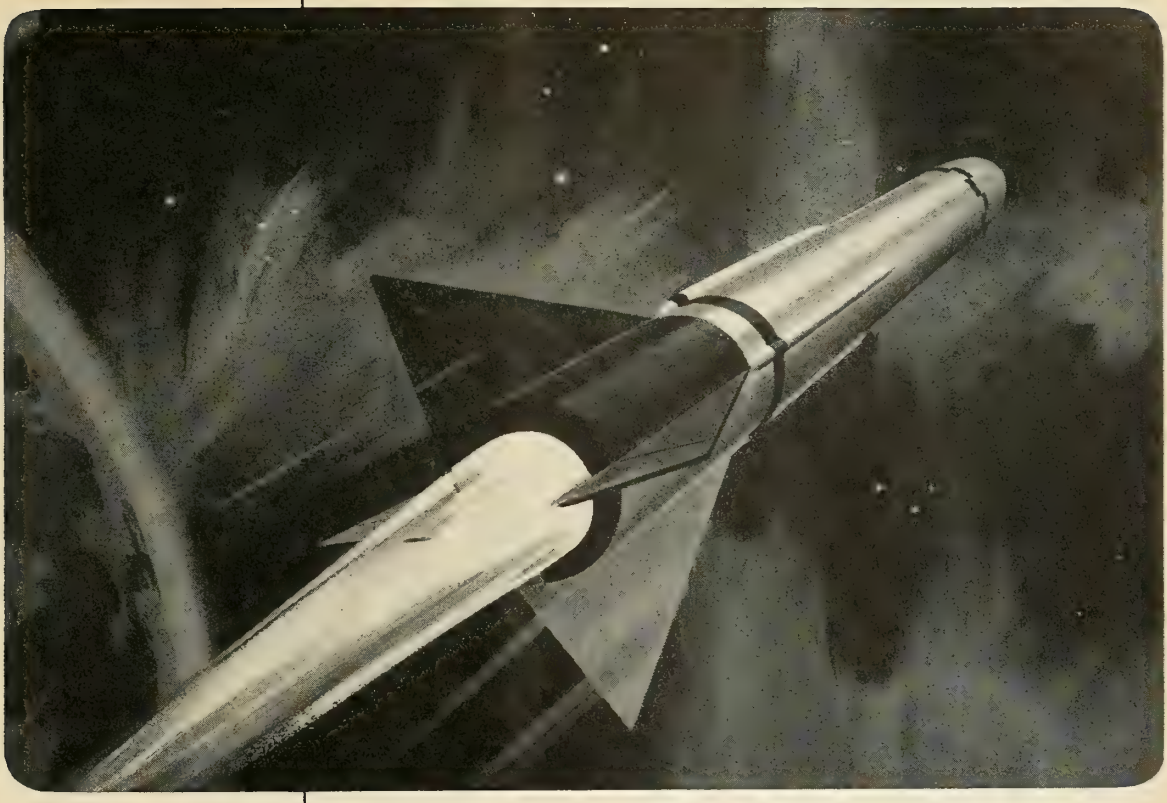
The effects on selection of a propellant for an underwater missile application are threefold: (1) the generator pressures are much higher, (2) hygroscopic propellants are undesirable, and (3) the ambient temperatures are less severe.

Higher pressures require heavier gas generators to maintain safe stress levels. While liquid monopropellant performance is relatively unaffected, the solid propellants are greatly affected. Both composite and double-base solid propellants increase burning rates as the generator pressure increases.

This phenomenon necessitates the use of longer grains than would be required in an air missile for the same duty cycle. Of course, the "mesa" type discontinuity exhibited by double-base propellants tends to minimize this dependence of burning rate on pressure as indicated by Figures 1 and 2.

The hygroscopic properties of certain propellants would be disadvantageous in underwater missile use. The effects are more severe with solid propellants than with liquid monopropellants. Absorption of water by a solid propellant results in erratic ignition and combustion, and ash in the propellant gases.

The effect of ambient temperature, as with hygroscopicity, is more severe on solid propellants than on the monopropellants. Except for such items as the boiling point and the freezing point, liquid monopropellant performance is relatively unaffected. Of course, additional energy is required to initiate decomposition, but the energy difference is not too significant.



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Propulsion Notes

By Alfred J. Zaehringer

Big push is now for expansion in LOX generating and transportation equipment to power our new line of ballistic missiles (all using LOX). Office of Defense Mobilization and the Business & Defense Services Administration now offer fast tax write-offs if producers can turn out LOX and nitrogen of at least 99.5% purity. Other conditions: LOX-nitrogen production ratio must be 4—1 and delivery to military customers must be assured. Latest new LOX plant will be a $9 million unit at Acton, Mass. for Air Reduction. Overall, the firm is expanding oxygen facilities by at least $20 million. Linde is to expand its oxygen facility at Ashtabula, Ohio by $12 million with similar boosts at East Chicago and Kittaning, Pa.

Improvement of the standard dewar flask—used for storing LOX and other liquefied gases—has been reported at Bureau of Standards, Cryogenic Engineering Laboratory, at Boulder, Colo. Evacuated powders such as diatomaceous earth, perlite, and silica aerogel have been used.

First tank-car shipments of Westvaco Dimazine were recently made by Food Machinery from its S. Charleston, W. Va. plant. The fuel, dimethylhydrazine, now goes into the *Nike* and other new missiles.

Improved physicals in hypergolic white fuming nitric acid systems is claimed in a new patent granted the California Research Corp. The firm found that addition of 4% sodium nitrite to a 96% WFNA-4% water solution lowered the freezing point to —97°F. In addition, a similar mixture could be stored at 122°F for 48 hours without gas evolution. It is claimed that the mixture does not greatly increase the ignition delay in most hypergolic systems.

Relation of chemical structure and "hypergolicity" of amine fuels has been suggested by RMI. For best hypergolic operation, the rules are: have one C-H bond at the alpha-C in an aliphatic primary amine; use a methyl group in place of a secondary H atom; don't use a methyl group for a secondary H further away from the N than the alpha-C; use amine, hydroxyl, or phenyl groups on the beta-C; alkyl in primary saturated aliphatic amine should be myl; in secondaries it is outyl; in tertiaries it is propyl. With the same number of carbons, tertiary amines are best, next come secondary and are followed by the primaries.

New partnership on the horizon: Gulf Oil Co. and Mine Safety Appliances Co. (a subsidiary of Callery Chemical) will cooperate on joint efforts in the field of high energy fuels and boron chemistry.

Standard Oil Co. (Ind.) has a new hypergolic fuel for use with nitric acid. The liquid is made by pyrolysis of hydrocarbons from butane, butylene, ethane, gas oils, naphtha, propane, and propylene. For hypergolic operation, the acid content has to be at least 95%.

In experiments with a hydrogen-fluorine torch, Temple University researchers have hit a maximum flame temperature of about 4300 K. Composition was 54% hydrogen and 46% fluorine.

French experimenters are using a turbo-reactor to study the combustion of hydrocarbons with an eye to understanding the combustion of kerosene. Work sponsored by the Ministry of Air under Rappeneau and Roy is turning up laminar and turbulent flame speeds, flame temperatures, and vaporization data. Another work by the same agency has concluded that in the combustion of substituted pyridines, this compound has a high anti-detonating power which is probably a result of its strong anti-peroxide formation reactions.

New stabilizer for nitrocellulose propellants has been disclosed by Hercules Powder. Some 0.2—2% of the substituted diphenylamines, urea, or dicyandiamide and 0.02—1% of citric, phosphoric, or stearic acid is blended with a nitrated cellulose to form a product of 13.1—13.2% nitrogen.

New Design Trends for

Harvey Aluminum Extrusions

To any experienced engineer or designer, aluminum extrusions are a common commodity. You don't have to tell him that extrusions offer such advantages as ease of fabrication, design flexibility, etc. He knows that. What he wants to know now are the newest advances made possible by the extrusion process.

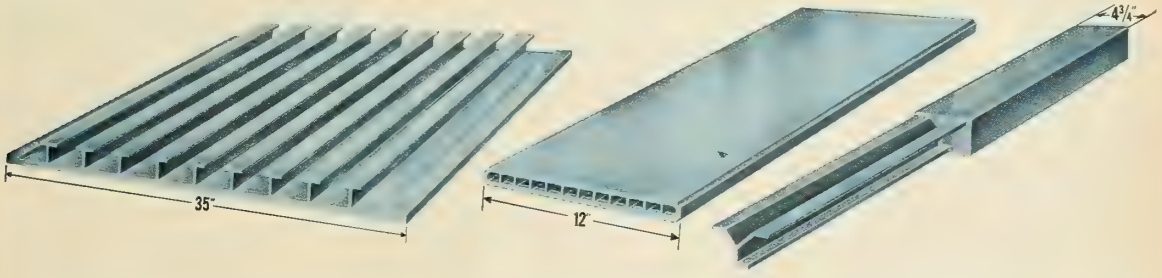
Potential for new configurations and applications

Typical new applications for Harvey Aluminum Extrusions are illustrated below. The design possibilities for aluminum extrusions are now practically limitless. Large heavy press sections; unusually complex shapes; wide, integrally stiffened skin panels; solid, hollow, and stepped extrusions; and extra long thin sections can be obtained from Harvey in all aluminum alloys. Heat-treated shapes can be produced in lengths up to 80 feet, weighing as much as 2,500 pounds. The maximum circumscribing circle diameter practical is 25½ inches. For functional, structural, or decorative applications demanding custom design plus light weight, corrosion resistance, high strength, and a naturally attractive finish, Harvey Aluminum Extrusions are first choice. And remember, Harvey is traditional for high quality and service.

Harvey Aluminum leads in extrusions

Harvey's completely integrated facilities include a large complement of extrusion presses ranging in size from 1400 tons to 12,000 tons, stretch-straighteners up to 3,000,000 pounds capacity for lengths up to 105 feet, and the newest supporting and finishing equipment.

If you have a problem with extrusions, thoroughly qualified Harvey specialists are always ready to help you improve your product. Write to Harvey Aluminum Sales, Inc., Torrance, California, or contact the nearest sales office listed under "Aluminum" in your classified telephone directory.



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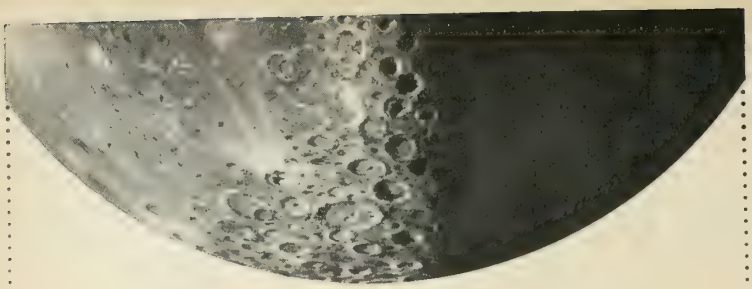
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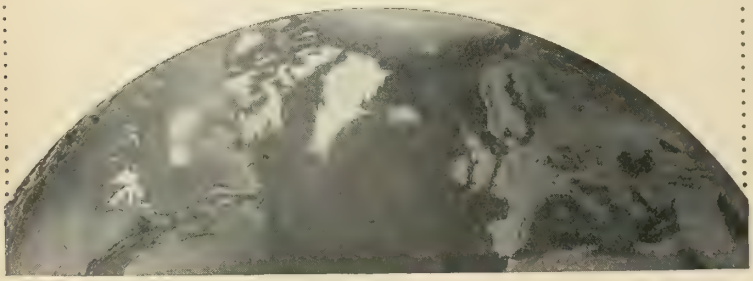
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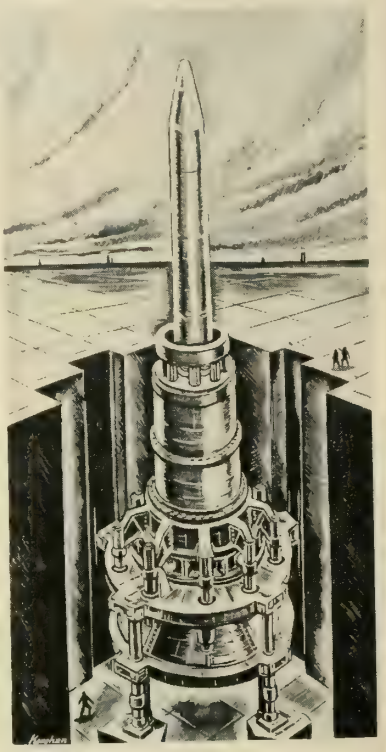
BUILDERS OF POWER FOR OUTER SPACE



engineering briefs

Loewy Contract For *Polaris*

The Loewy-Hydropress Division of the Baldwin-Lima-Hamilton Corp., New York City, has been awarded a contract by the Navy for design and construction of a full-scale ship-motion simulator for testing the Fleet Ballistic



POLARIS ship motion simulator.

Missile, *Polaris*. The device will be installed at Patrick Air Force Base in Florida.

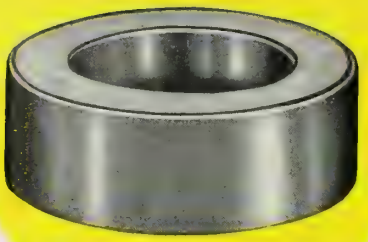
Ship motions will be reproduced from magnetic tape recordings taken at sea. The unit will be capable of conducting actual test firings.

Magnesium Extruder For Missile Output

The Dow Chemical Co. announces completion of a 13,200-ton extrusion press, the largest in the world for extruding magnesium, the second largest for non-ferrous metals. It is expected to be especially useful in the production of round hollow tubing for missile bodies. It is able to produce integrally stiffened sections from nine to 20 inches wide; I beams from 11 to 28


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Photon powered interplanetary craft
Speed: 186,000 Miles Per Second
Travel Time to Nearest Star: 3.6 years
Man's most elaborate thoughts on interplanetary travel now involve a photon powered craft whose speed would be that of light, 186,000 miles per second. This would make travel time to the nearest star, Alpha Centauri, about three and one half years.
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	I.D.	O.D.	Strip Width	I.D.	O.D.	H		I.D.	O.D.	Strip Width	I.D.	O.D.	H
47	.500	.625	.125	.440	.685	.195	75	1.250	2.000	.375	1.170	2.110	.445
2	.500	.750	.125	.440	.820	.195	15	1.500	2.500	.500	1.400	2.600	.600
37	.625	1.000	.188	.570	1.085	.262	16	1.625	2.000	.250	1.525	2.110	.330
3	.625	1.000	.250	.570	1.085	.340	17	2.000	2.500	.500	1.860	2.652	.610
5	650	.900	.125	.585	.975	.195	58	2.000	3.000	1.000	1.860	3.152	1.188
79	.750	1.000	.250	.665	1.085	.340	76	2.000	3.000	.500	1.900	3.100	.610
7	.750	1.125	.188	.665	1.215	.262	18	2.500	3.000	.500	2.360	3.152	.610
9	1.000	1.250	.125	.915	1.340	.195	19	2.500	3.500	.500	2.313	3.688	.688
30	1.000	1.250	.250	.915	1.340	.320	20	2.500	3.500	1.000	2.313	3.688	1.188
10	1.000	1.375	.250	.925	1.455	.320	21	2.500	3.750	1.250	2.313	3.938	1.438
39	1.000	1.500	.250	.925	1.570	.320	22	2.500	3.750	1.500	2.313	3.938	1.688
62	1.000	1.500	.500	.925	1.570	.610	23	3.250	4.500	1.500	3.062	4.688	1.688
11	1.000	1.500	.375	.925	1.570	.445	77	3.250	5.000	1.500	3.062	5.188	1.688
13	1.250	1.750	.250	1.170	1.820	.330	25	4.000	5.250	2.000	3.813	5.438	2.188
29	1.250	1.750	.500	1.170	1.820	.610	78	4.000	6.000	2.000	3.813	6.188	2.188

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COMPANY

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engineering briefs

inches high; round tubing from a 10-inch to 24-inch outside diameter. It boasts a 3000-ton piercer for optimum simplicity in producing hollow extrusions.

Diversey Builds New Missile Plant

Diversey Engineering Co. president J. H. Kauffmann has announced construction of a new $250,000, 31,000 square feet plant at Franklin Park, Ill. Planned especially for missile work, it will have the most modern contour milling equipment, largest Monarch Air Gage tracer lathes and will be equipped to work on titanium, inconel, A-286, Haynes stellite and zirconium.

Colloidal Graphite Used In Satellite Construction

Colloidal graphite suspensions, supplied by the Acheson Colloids Co., Port Huron, Mich., are used as a lubricant and parting agent during the deep-drawing and spinning of the satellite's magnesium sphere. After the naptha carrier has evaporated and left a tough thin graphite film on the magnesium, the sheet is preheated to 600-650°F. The prelubricated hot sheet is then deep-drawn into a hemispheric shape by a 750-ton hydraulic press.

Brooks Perkins, Inc., manufacturer of the spheres, says "ten to fifteen or more" are to be built for testing and actual firing.

Cambridge Reveals New LOX Facility

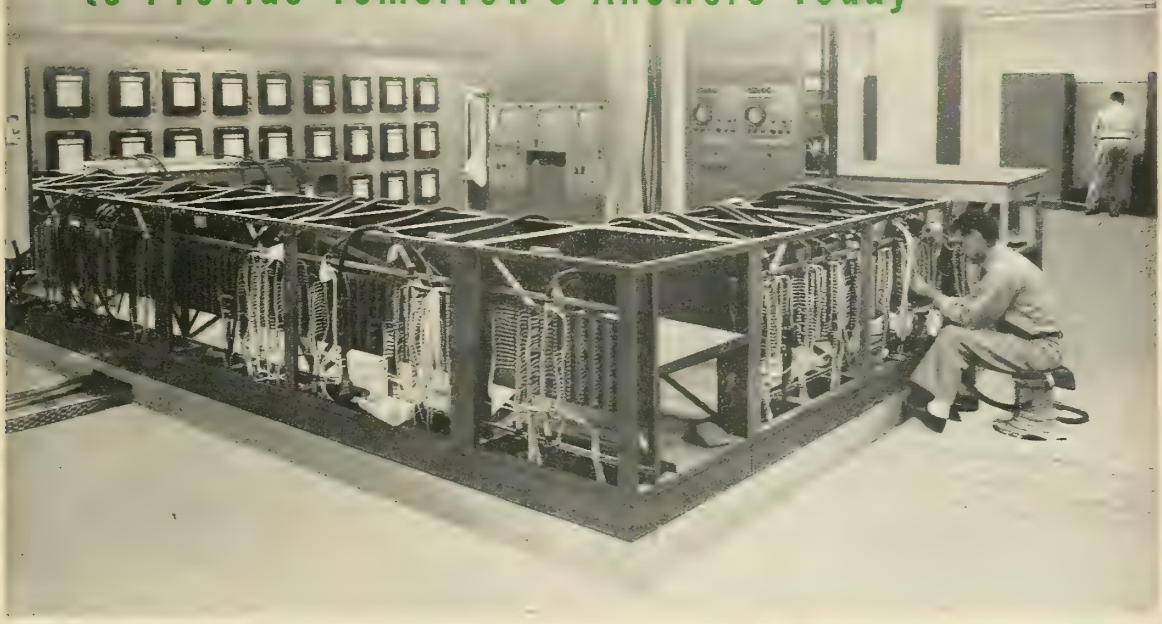
Cambridge Corp., Lowell, Mass., has revealed details of its new liquid oxygen loop project R-1, the first commercially available facility of its kind in the U.S. The liquid oxygen cold flow test facility is available to private industry for testing performance and reliability of rocket and missile equipment in the cryogenic field.

Army Engineers' A-Plant Is Air Transportable

Last month the public was given its first look at the Army's prototype package power reactor, designed to be air transportable to advanced bases, such as, for example, missile launching bases. Designed by the Atomic Energy Commission and built by Alco Products Inc., Schenectady, N. Y., the first APPR (Army Package Power Reactor) will be used primarily for test and development. Its rated output is 1855 kilowatts.

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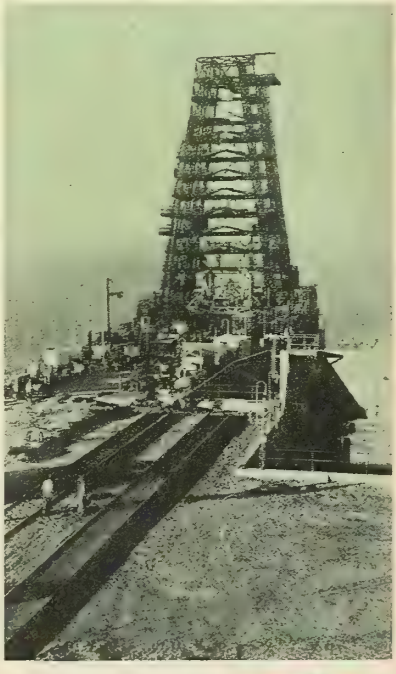


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Submariner "Swede" Momsen

On undersea warfare, 60-knot submarines, high-speed underwater guided missiles and hydrodynamic boundry layer control

Naval Academy graduate Vice Admiral Charles B. Momsen, USN (Ret.), is Mr. Submarine. Developer of the famous Momsen escape lung, he has pioneered undersea warfare since just after World War I. Now retired, he is anything but inactive but, as a fast traveling consultant to industry, leads the nation's thinking on the eve of the submarine's greatest era of development—peaceful and military.

Q. *Admiral Momsen, will you tell us how the strategic role of the submarine compares past, present, and future?*

A. In referring to the past, I'll take World War II. Then the submarine was handicapped. It was slow and was restricted in its ability to stay submerged. It was referred to as a weapon of opportunity because it had to be pretty much in the path of the target it was seeking to attack.

Q. *What were the underwater speeds?*

A. In the beginning of World War II, the maximum submerged speed was nine knots, and if the submarine ran at nine knots it would only run for about one hour before it ran its batteries down. Its top surface speed was 18 knots. German submarines started out with about the same speed characteristics, but they improved their underwater propulsion system by using thin plate batteries with greater capacity. Toward the end of the war they had one submarine which we believed could make 26 knots.

Q. *Was that with the hydrogen peroxide motor?*

A. Yes. That was the Walther cycle, and hydrogen peroxide with diesel engines. That submarine didn't actually get into the war but it was the forerunner for some work that we've done. They built one working prototype. It was undergoing tests when the War ended.

Q. *Wouldn't the Russians know that design?*

A. Oh, yes.

Q. *The Russian submarines are supposed to be based on the German Type XXI long range design, aren't they?*

A. Yes.

Q. *What can you say about the type XXI's range?*

A. Well, when we refer to long range submarines we refer to those capable of operating 5,000 miles away from the bases. A great many of the Russian submarines listed now as you know are quite old, but on the other hand they are building new ones and unfortunately we don't know too much about their characteristics.

Well, we're still talking about the strategic role of the submarine which at present is undergoing an evolution. We're getting now to higher speeds and greater submerged endurance, but no one has a complete fleet of that type of submarine as yet. We can't say that the present is changed much from World War II, but the future holds a great deal of change. I think the future submarine will have mechanical endurance that's practically unlimited. It will have speed capabilities as high as 60 knots underwater. You can never make it on the surface. A submarine inherently will be able to make more speed submerged than on the surface. The reason for that is that a submarine completely submerged and two or three diameters below the surface is freed of wave making losses.

Q. *Can you speculate on future under-sea warfare?*

A. Yes. With the high speeds which will be available to submarines, they will pass from the category of the weapon of opportunity to a weapon which creates its own opportunity, and of course the strategic role will be very much improved because they can get to more places on more assignments and possess a much greater technical capability when they get there. An animal confined to the surface of the water is limited in its tactics to two dimensions of travel. The birds and fish who operate in three dimensions have an inherent tactical advantage. Therefore, I believe that when the submarine is fully developed, or as



Future submarines . . . will do 60 knots.



In three dimensions . . . an advantage.



Fish have nerve ends in their skin.

fully developed as the aircraft, surface ships will not be able to protect themselves. It follows that in the not too distant future control of the sea may well be by submarines and aircraft. I feel that this is coming.

I think you will remember that toward the end of World War II, the Germans had prepared a V-2 or V-3, I think perhaps a V-3 missile, in a container which was to be towed behind the submarine to our coast off New York City.

It all points to the fact that the submarine had that capability. At the present time, as you see, we're bringing our submarines up to the surface and launching from the deck, but I feel that eventually we'll be able to launch missiles through tubes and they will be either torpedoes which operate entirely in the water, or will come to the surface and become airborne for various purposes, intercepting surface ships or aircraft through the use of radar.

Q. *Will 60 knots for the submarine be faster than, say World War II torpedoes?*

A. Much faster. The fastest torpedoes that we knew of were around 45 knots, but that was fast enough for the target which they were seeking in World War II. I believe that no matter how high the submarine speed will get we'll always be able to make a torpedo go faster, simply because the torpedo doesn't have personnel in it.

Q. *What was the outside range of the torpedo that we used during World War II?*

A. Approximately 10,000 yards.

Q. *Does this apply to the straight run torpedo or sonar guided for both?*

A. That was a straight run and fairly slow speed, about 30 knots. Our torpedoes had two speeds, high speed for short range and low speed for longer range.

Q. *Am I correct in assuming that the reason for emphasizing the quietness in torpedo propulsion is that you don't jam your own homing devices that way?*

A. For a homing weapon there is always a battle between the self noise and the noise of the target, and the weapon has to be quieter than the target by quite a margin because it's listening to a target at some distance away. But, submarines versus submarines is much like Indian warfare. One has the advantage of not being committed to move. He can lay quietly in one place. The other one has an objective to go through, and to accomplish this he must move. This makes a certain amount of noise.

Q. *Sonar has been the primary basis for torpedo guidance. Are there any other methods that might be used?*

A. Well, in general electro-magnetic waves do not penetrate the sea and therefore, one way or another we have to rely on sound for the exchange of intelligence whether it's a torpedo or a communications system.

Q. *Isn't there a sound refraction problem in the ocean that can get quite severe?*

A. It is a very difficult problem. What actually refracts sound is the change in density. The speed of sound is a function of the density, and the greater the density the higher the speed of sound.

Q. *What effect does this have on homing torpedoes?*

A. An acoustic torpedo is always aiming at the noise source. It may be a long way around but eventually it arrives at its target.

Q. *We understand that the fish are not concerned with such things as cavitation, that flight, often at high speeds, is remarkably silent. Do you feel that performance of man-made water vehicles might be improved through careful study and emulation of fish design?*

A. I would think so. We have no known hydrophone that can record the noise of a fish traveling through the water.

Some fish hit speeds of around 50 knots, and they're highly maneuverable. The porpoise is fairly fast; the barracuda is very fast. But I don't think we really know how fast they can go because very fast fish rarely have the urge to go at their top speed.

Q. *They never cavitate?*

A. Never, unless they are very close to the surface. Cavitation is a function of pressure, and if they get very close to the surface, well, then they get less water pressure around them and are apt to cavitate. But I have seen barracuda come right up to the window of a diving bell at very high speeds, stop suddenly with not the slightest sign of cavitation, no noise and look at you for a few seconds and then like a flash he's gone again and still no sign of cavitation. I've done some work with the Coleman Engineering Co., in Los Angeles on the matter of hull cavitation and the reduction in drag. Dr. Max Kramer, a German scientist working with them, has been studying this subject for quite a while, and we believe that he has solved the riddle as to what causes cavitation and how to prevent it and promises a very substantial reduction in drag.

That work is a private venture and is not being supported by any of the military. Very often we get very fine things from private projects.

Q. *Can you say anything concerning when the prototype with a 60 knot sub might be launched?*

A. I haven't the slightest idea. I notice that about two weeks ago in the *New York Times* there was a very small article that said the British were developing a very high-speed submarine. It's feasible, it's coming. There's no question about it's coming. The question is whether the effort will be put into it.

Q. *Effort means dollars?*

A. Well, that's right, hard rocks. Dollars, and there



If flow is laminar . . . noise is reduced.



Torpedoes . . . will become airborne.



The sea is still a place to hide.

are some technical developments, too, that we think are feasible. There aren't any problems that can't be solved.

Q. *Does anyone know why fish don't cavitate?*

A. Well, cavitation is caused by unequal pressures along the side of the surface, as it moves through the water.

Q. *Is cavitation equivalent to going from laminar to turbulent flow in the boundary layer?*

A. Exactly the point. The difference between turbulence and laminar flow is the unequal pressures along the surfaces. It's my feeling that the fish has nerve ends in its skin and that unequal pressures are uncomfortable. Through muscular effort he makes minor changes in his shape and keeps the pressures equal and therefore, the flow laminar. And if the flow is always kept laminar you will not have turbulence, and your water noise will be reduced.

Q. *Might you not then, where you tend to cavitate, blow in or suck off water to maintain laminar flow?*

A. That's right. It's the same approach, but in aircraft turbulence results in increased temperatures plus increased drag whereas in the submarine, it's increased drag and increased noise. And, if submarine turbulence can be controlled through the control of the boundary layer it will be applicable to propellers as well.

Q. *Do you personally feel it would be practical to develop a medium range ballistic missile capable of fitting and being fired from the torpedo tubes of submarines now in service?*

A. Not necessarily from current torpedo tubes. We have been locked to a 21-inch tube for many years. The Japanese increased theirs to 24 inches. There's no reason why we shouldn't use 24 inches or even 48 if we had a purpose for it.

Q. *Just to get complex for a moment, do you see any future need for a transitional missile that starts out traveling underwater; then rises to the surface and becomes ballistic; then reenters the water to act like a torpedo again?*

A. That sort of thing might be needed for a restricted submarine, but not the submarine of the future.

Q. *Well, suppose we had an underwater distant early warning system—a network of sonar buoys spotted around our coasts. We wouldn't need as many anti-sub submarines on patrol. A submarine off New York equipped with such a missile could attack an enemy submarine off Cape Cod.*

A. Then it wouldn't have to travel underwater first, except to float to a safe vertical firing position. Only two stages would be required. That is something that is under consideration. There's no need for three stages. I'd like to suggest also that such a sonar buoy network would be readily subject to destruction by the enemy.

Q. *Would this be true of passive devices?*

A. In the defense against future submarines, if they're going to be as quiet as I think they will, there will have to be more than just passive sonar. An active system could be traced by its own signals.

Q. *What was the range of passive sonar in 1945?*

A. By World War II the Germans could hear a large surface ship perhaps 75 or 80 miles away. They could hear convoys with ease at 30 or 40 miles.

Q. *Can we assume this has been improved?*

A. Yes. We can hear depth charges, for instance, tremendous distances, several hundred miles.

Q. *Can you get direction and estimate range?*

A. You can get a pretty good direction fix but no range. Underwater sound is a very interesting subject because we have in the past been thinking only in terms of the spectrum of sound that the human ear can hear. We haven't investigated the very low frequencies or the high frequencies beyond the oral range. There is a principle that we'll have to keep in mind that the higher the frequency, the greater the attenuation of the sound in water. In other words, very high frequency can be heard at only very limited ranges, where very low frequencies travel perhaps thousands of miles. That is the nature of sound in water.

Q. *What are the limitations of underwater warfare?*

A. Well, there are three areas of limitation. One is communication; the second is navigation; and the third is human endurance. Now we've talked quite a lot about underwater communications and so far as we know at the present time sound is the only means of communicating completely underwater. Low frequency radio penetrates the water a little bit, a matter of a few feet. From a navigation standpoint, I think a great deal can be done. Nowhere in the ocean is land more than five miles away vertically. We can put navigational fixes on the bottom just the same as we do navigational beacons for aircraft on land. From the standpoint of human endurance, that is a problem everywhere and in every endeavor of life we have to provide fresh water and air to breathe.

However, if we look again at nature we find fish are able to get oxygen which is in solution in the sea water and have their CO_2 carried off in the sea. This is the same process of the human lungs, except that we expose air to a membrane. Now in the ocean there's much less oxygen in a cubic foot of sea water than there is in a cubic foot of air. Therefore, great quantities must flow over the membrane. If we can ever become as smart as nature why we'll have all three problems solved. It's quite interesting that fish maneuver so well together. You see a school of fish make a radical change of course simultaneously without collision. Fish will spawn in a river and go to sea and disappear hundreds of miles away, maybe thousands, and yet the following year they come back to that same river.

Q. *I would like to ask you whether you think the submarine is the best weapon against another submarine?*

A. I believe that it is. I have been advocating that for some time. I believe that the submarine has inherent advantages over another submarine that nothing else has. Some people in the Navy now say that we shouldn't have submarines that are specifically designed for anti-submarine roles, that all submarines should have those roles. I have never believed in that because I think that if you have a very important mission for any ship or plane, that it ought to be built for that mission.

Q. *What do you see as the peaceful future of underwater development?*

A. That is another area in which I am doing work now, and it's quite interesting. The U.S. Rubber Co. is working on underwater fuel and cargo transport by means of rubber barges. We can make these rubber containers of considerable size. They can be towed by a submarine and I believe that it will be financially or economically feasible to transport fuel, grain and other bulk cargo, cargoes that can withstand the sea pressure. You've got two advantages there. One, less drag under water than on the surface. Two, the bulk of your investment, the tow boat, doesn't have to sit in port for three weeks while they load and unload it. Also, it is free from wave motion and wind and storms. For the return trip this container can be rolled up and carried on the deck of the ship and you don't have to tow an empty ship in ballast on the return trip. You don't need a long tow line because you don't have the motion of the sea to work against and because of the nature of the material, rubber being flexible, you can violate all the laws on length-to-beam ratios that are required on ships. You could make one of these containers 20 ft. in diameter and a mile long if you want to.

Q. *Of course, for military purposes again it would be invaluable.*

A. Yes, safety concealment from attack. The sea is still a place to hide. ★

Rocket Propellants for Underwater Missiles

By Alfred J. Zaehringer

THE ROCKET POWERPLANT now allows the underwater missile spectrum to be expanded to include other subs, ships attempting evasive action, anti-sub patrols, and even distant land targets.

The advent of rocket and nuclear power has given the submarine a new lease on life. Atomic power gives the sub an almost unlimited striking range while rocket power can replace the conventional torpedo or deck gun. The main purpose of the modern sub will thus be to carry out atomic strikes on distant land targets—while remaining conveniently submerged.

Environment (Care)

To the landlubber rocket engineer, two environmental conditions are encountered—pressure and temperature.

The underwater pressure is a product of depth and density. With seawater (density about 64 pounds per cubic foot) about 33 feet of depth raises the pressure one atmosphere. Thus, at a depth of 60 feet, the pressure is about 60 psia.

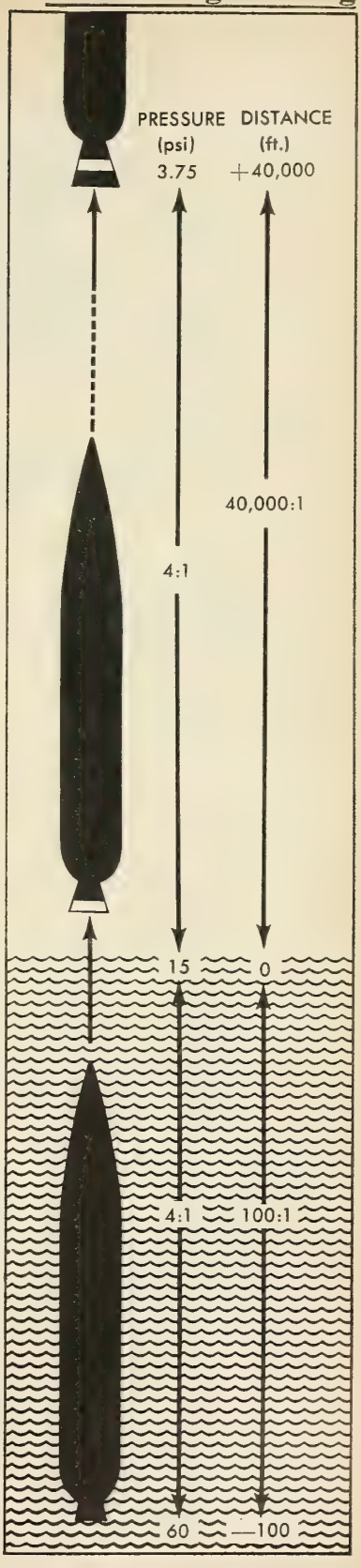
For optimum expansion the nozzle should expand the combustion gases to ambient pressure. Thus, as the missile rises vertically, the pressure decreases, and the nozzle has to get bigger. Therefore, some optimum expansion point has to be selected.

It is perhaps fortunate that a vertically ascending missile will be under greater than atmospheric pressure for only a short time. However, the difference in thrust (and overall pressure system) must be taken in account.

It is interesting to note that at a depth of only a few feet, water pressure can be helpful, in effect increasing the nozzle length without adding missile weight; this effect, useful in rocket torpedo work, acts to increase the thrust coefficient. Since subs can operate at 200-300 feet, operating normal liquid rocket engines poses some problems:

How do you operate at a chamber pressure of 300 psia when the outside pressure is greater (pressure at 300 feet is about 320 psia)? What is the optimum expansion ratio for rapidly changing pressure? What about variable combustion pressure? Not only are propulsion problems difficult but structures must be beefed up to take the higher external pressures.

How far down would you want to fire an IRBM? For a missile nearly 100 feet long, the depth would have to be 100 feet so that the missile is still submerged. It appears the depth would be 200-300 feet for maximum hiding.



Pressure difference (4:1) to depth of 100 feet is about same as from sea level to 40,000 feet. This calls for increasing nozzle exit area for optimum expansion.

Table 1

PROPULSION SYSTEM PARAMETERS

Type	System	Performance	Hazard	Cost	Storage
Liquid	LOX-Fuel	H	V-L	Low	NP; OB
	Acid-Fuel	H	V-L	Medium	EX; OB; IB
	Peroxide-Fuel	H	L	Medium	EX; OB; IB
	Peroxide-Cat	M	L	Medium	EX; OB; IB
	Ethylene Oxide	M	L	Medium	?
	Alkyl Nitrate	M	L	Medium	?
Solid	Composites	H	Low	Low—Medium—High	EX
	Double-Base	H	Medium	High	TS

H: over 200 lb sec/lb
M: below 200 lb sec/lb
NP: not practical in missile
V: Vapor
L: Leakage
EX: Extended periods
TS: Temperature sensitive
OB: Outboard
IB: Inboard



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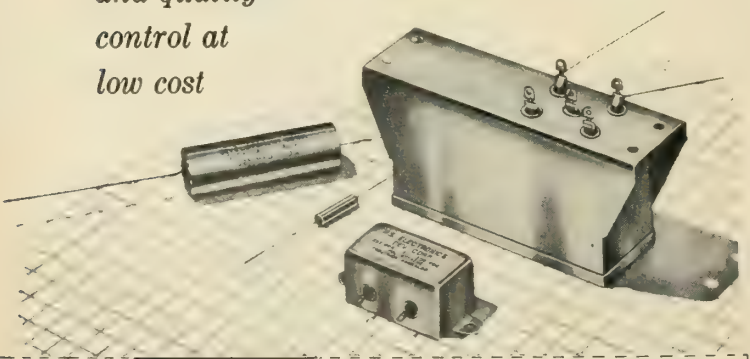
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Possibly one item of consolation—sea temperature could be quite useful. For one thing, the surface temperatures have a narrower fluctuation than on land. The upper limit is 80-85°F in the tropics and seawater freezes at 28-29°F. Thus, the temperature range is only 50-55°F. Within a given season, the variation is less than 10°F and about 1°F between day and night.

As you go down, the temperature the world over tends to become lower and constant—the average is about 34°F. Thus, we have a gigantic constant temperature bath and an exposed underwater missile will not operate under such wide temperature extremes as experienced by land or air missiles (viz., —80° to 180°F). It is conceivable that if needed heat could be fed to the missile to maintain higher operating temperatures.

In a vertically ascending missile, the effects of waves would have to be considered. When breaking the surface, the missile would not yet be moving fast and would be vulnerable to waves and then the winds.

Since timing might be critical against a land (or air) target, a calm sea can't always be counted upon. A breaking wave on a solid object, for example, can generate pressures of 2,000-14,000 pounds per square foot over a time span of 0.05-0.005 sec.

The variation of wave height with wind speed will certainly be instrumental in determining when to fire—particularly a large ballistic missile.

Other factors, too, are important. For long-range missiles designed to operate entirely underwater (such as anti-ship or sub), guidance and control systems will have to take care of varying currents or shifts in currents. Action of seawater on structures, especially where missiles are immersed for prolonged periods, is also important.

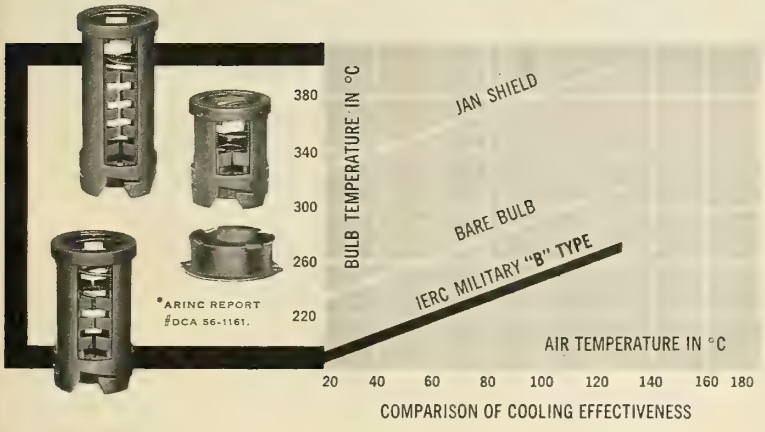
Not only is it a matter of preventing corrosion and barnacle growth but you also have to worry about keeping out water. This is quite different from land or air missiles.

Propulsion (Feeding)

The selection of a propulsion system for an underwater rocket is governed by such factors as performance, storage, hazard, etc. Such parameters are presented in Table 1. Of the liquid propellants, LOX systems are not attractive for ready-to-go storage in missiles for extended periods of time.

However, all liquids offer one large headache for naval service: leakage. In addition, a very high degree of reliability is required and, at the present time, this reliability could best be offered by solid systems. Solids can now give ready-to-go systems which

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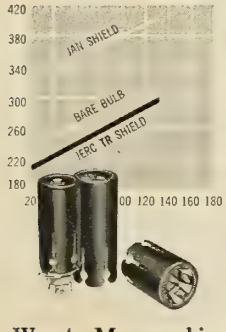


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can be stored for over a year with zero maintenance.

Maintenance, however, may not be a strong objection if the sub's prime mission is to launch an IRBM. Of all the liquid systems, the nitric acid propellants can come close to meeting all requirements.

Because of relative insensitivity to low temperature operation, and ability to operate at high pressures (1000-2000 psi), the composite solids would be ideal for underwater use. Other advantages are: grain designs can allow for a programmed thrust (and pressure).

In addition, there are the mesa composites where burning rate is independent of pressure in the 1000-2000 psi range. This is advantageous since the effects of back pressure can be absorbed and the grain geometry can allow for the best mass flow (including a variable mass flow) during a rapidly decreasing sea pressure.

Internal storage systems could be used for smaller missiles (rocket torpedo or flak) of both the liquid and solid variety. Deck pods could be used for large missiles where the sub's crew could be used for servicing the missile.

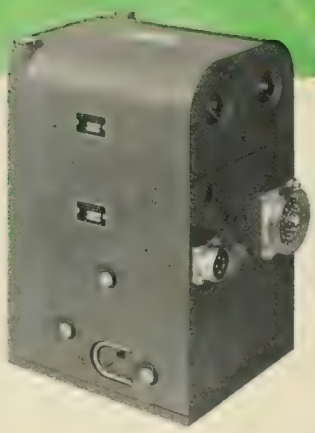
Towed pods would be attractive for very large systems or for the high hazard liquids. Another advantage of a towed pod is that it could be jettisoned on completion of the mission or could be dumped if necessary to save a sub.

It is thus seen that missiles will breathe new life into the submarine. The impact on naval strategic and tactical warfare will be as great as nuclear power. With such subs, the age of the present highly vulnerable aircraft carrier is rapidly coming to an end. The salient features of the missile-sub weapons system are: unlimited range and striking power, relative independence of a vulnerable base, and the very great element of surprise.

Since 1955 the Russians have been completely independent of German brain power, although most of the current missiles reflect the German thinking that conceived them in their early stages of development. There is some evidence that the Russians are still using Peenemünde missile base in East Germany for underwater missile research projects.

All evidence indicates that Russia is now on its own in the missile field and is doing well. Missile enthusiasm abounds among the entire Russian executive class. The apparent attitude of Russia's leaders is to have large quantities of undersea missiles available as quickly as possible. As is the case with most Soviet weapons, the emphasis is on simplicity and reliability.★

engineered to ride a rocket

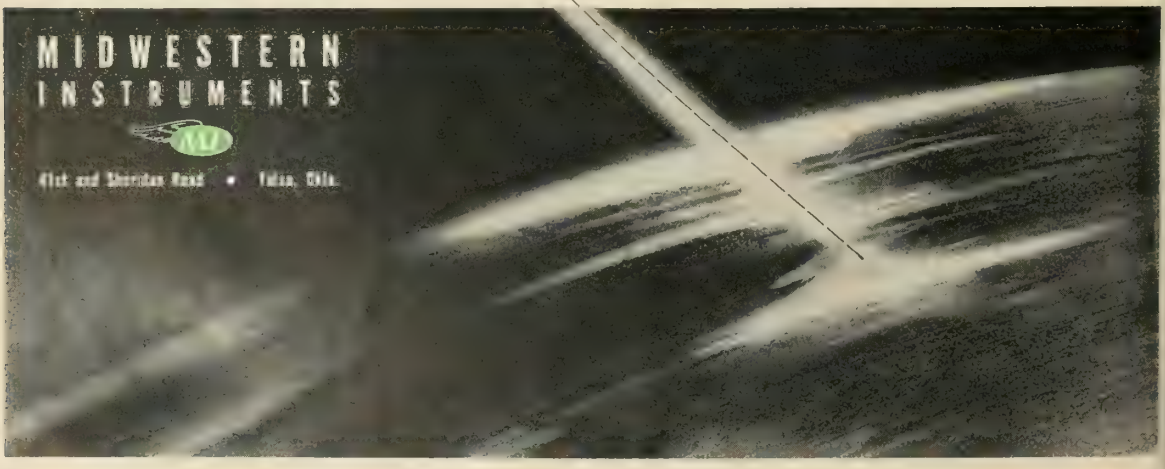


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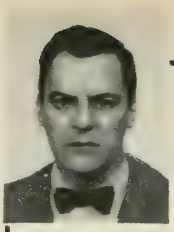
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Aerophysics

By Seabrook Hull

Being within a lifetime of extensive space travel, as we are now, certain basic concepts deserve more thoughtful consideration. Not the least of these are some of the fundamental hypotheses of relativity, at which point this column ventures into a phase of astrophysics.

An interesting and disturbing element of Einsteinian thinking is the "apparent fact" that the speed of light is constant to any observer, regardless of the relative motions of different observers observing the same light source. This, of course, is an awkward assumption. Yet wherever capable of being tested and checked, either astronomically or within the confines of some of man's more exotic research equipment, relativistic mathematics is meticulously born out.

If light velocity is constant for any observer, and we measure astronomical distances in terms of light-hours and light-years, then these distances (absolute spacial displacement) must vary for different observers. This concept does not appear to be at variance with relativity. Physical time also is dependent upon the relative motion of observer and observed. And, distance appears to be a function of velocity and time in any coordinate system.

Thus man, in his proximate ventures into outer-space, would seem to be limited in velocity only in terms of earth-bound observation. Relative to the coordinate system of the space vehicle itself, the velocity of light will remain constant, notwithstanding the velocity of that vehicle. This is one of the disturbing but essential assumptions of the General Theory of Relativity. Thus, the velocity of a free vehicle in space seems to be theoretically without limit. Again, relative to an observer on earth, this vehicle's observed velocity would be limited to a fraction of the earth-measured velocity of light.

However, in terms of the "absolute" coordinate system of the space-traveling vehicle itself, there would be no such restriction . . . for the only relativistic limitation on the vehicle's velocity is that it cannot exceed that of observed light. Yet this is constant for any observer, and regardless of the relative motion of that observer, the velocity of light is the same—186,000 miles-per-second. Thus a vehicle covering light-year distances (as observed on earth) in hours would still be traveling at less than the speed of light (as measured by the vehicle).

Pursuing this line of reasoning a few steps further becomes very disconcerting. For example, distance must thus be a function (or friction) of the observer and inconstant by any comparison: Spacial displacement becomes a chance (or optional) variant.

These lines of reasoning, dwelling on so-called Eigen conditions, may well be open to considerable argument, but this column hopes they serve at least to emphasize the real, practical need for: (a) Relating basic thinking theory to upcoming operational problems and (b) reexamining and justifying Relativity in terms of the many more recent (and startling) subnuclear observations. It would also seem to necessitate a new and more careful look at the concept of "free space" itself—the raising of the possibility anew that there is in fact a universal medium (once called the ether), a current source of confusion which, once comprehended, would become absolvent of some of the more fundamental anomalies. In any case, it should be obvious that Einstein's was an approach, not an end to understanding, that already more *thinking* is needed.

O.K. Mr. Satin?

Dr. Lloyd P. Smith

sident, Avco Research and Advanced Development Division

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w fields are under investigation and the division hopes to ke technical "breakthroughs" in magnetohydrodynamics, trolled thermonuclear fusion, conversion of chemical and lear energy into useful work, the creation of new materials, manned satellite, and many other areas. Some of these ds are so new that our laboratories must also be teaching ters so that young scientists and engineers who join us can rn the science and technology basic to these new fields while tributing their own creative investigations.

Lloyd P. Smith

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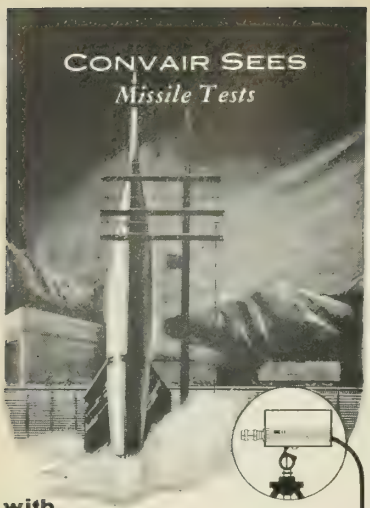
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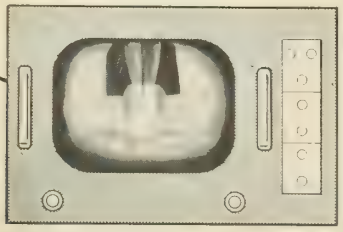
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Astrionics

By Henry P. Steier

When will the first *Vanguard*-with-satellite be fired? Seems like a good clue to the answer could be the status of the camera tracking station installations. Latest report from IGY scientists is that cameras will be installed at the rate of one per month starting this summer.

Since a dozen camera stations are planned, it looks as if the schedule for first attempt to place a satellite will be around July 1958. IGY starts July 1957 and runs to December 1958.

Big unknown about the earth and its continents is the distance between various points on earth's surface. Some guesses are that we are miles off in distance information between continental European and North American points.

Any planning for ICBM use would need most accurate distance information possible. Planned IGY camera tracking should add whole new orders of distance information accuracy to our fund of information. Data from cameras is expected to bring accuracy to within a few feet. Such information will be an important factor in data fed to big computers for calculating ICBM trajectories.

•

Recently a physicist came up with another idea on distance measurements. He said atomic powered submarines might be used to measure point-to-point distances between coastal areas. He suggested that the constant speed capability of these subs while submerged would make them useful for deriving distance from point-to-point times obtained.

First need for accurate distance information will probably be during ICBM test flights off the coast of Florida. These will be in the same general direction as the satellite launching. Recently reported was a plan to set up Air Force electronic missile tracking gear on the island of St. Helena off the African coast. Distance to that point, for example, would be most useful in evaluating ICBM tests.

•

Phase angle tracking systems similar to the Minitrack stations to be used for tracking the satellites' positions is "old hat" to the Cubic Corp. Similar systems built by Cubic have been in use at Patrick AFB for some time. Called DME-COTAR, phase angle measurements are used in this system for determining test missile trajectories, distance and position data. Operating at between 200—450 megacycles, tracking accuracy is said to be much better than with radar. Accuracies of two feet in distance at 200 miles and 0.03 mils in direction are claimed. Cubic expected it would get the Minitrack contract for the satellite program but lost out when the Navy developed its own system.

•

In the midst of speculation about whether the press will be permitted to view the first *Vanguard* launching is hope for on the spot viewing by the general public if the military will permit it. Rumor is that International Business Machines Corp. is negotiating to sponsor a big TV broadcast of the event.

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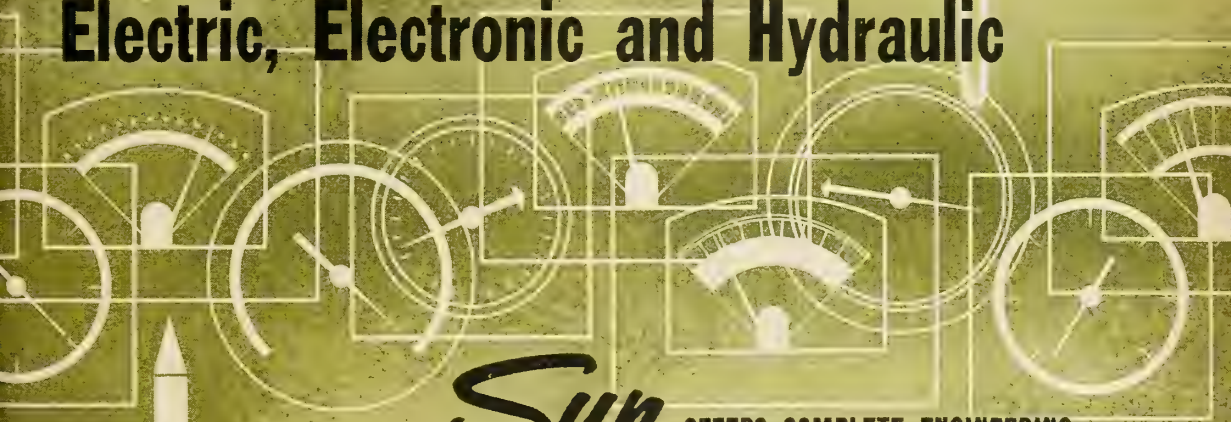
Note to lady rocketeers: A Latin American gentleman has a suggestion on how to shorten the time to moon travel. Dr. John P. Hagen, Project *Vanguard* Director was asked at a recent press conference, "When will the first moon trip be made?" The inquiry came from Maximilian Garavito, Editor and Publisher, "Revista Aerea Latinamerico." Hagen said he preferred to answer in terms of money and engineering needed rather than time. Senor Garavito then said he saw no reason why, since Columbus discovered America using money from jewels pawned by Queen Isabella, the women of America could not give their "jewels and stocks" for the first moon ship.

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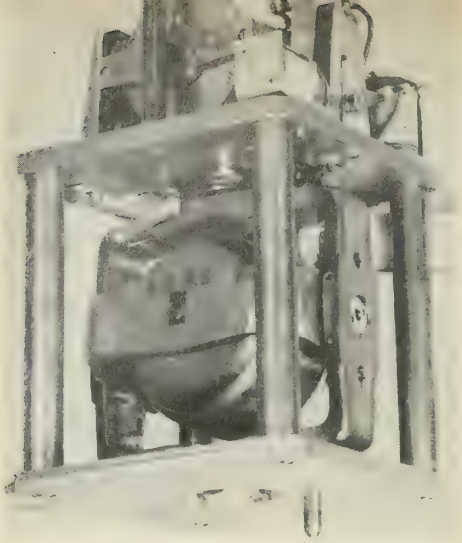
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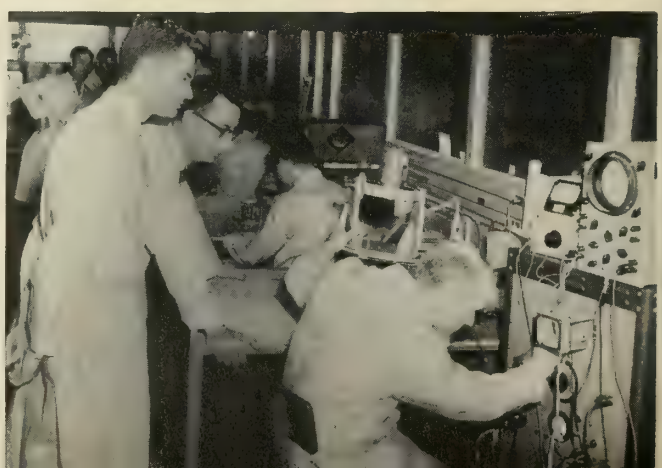


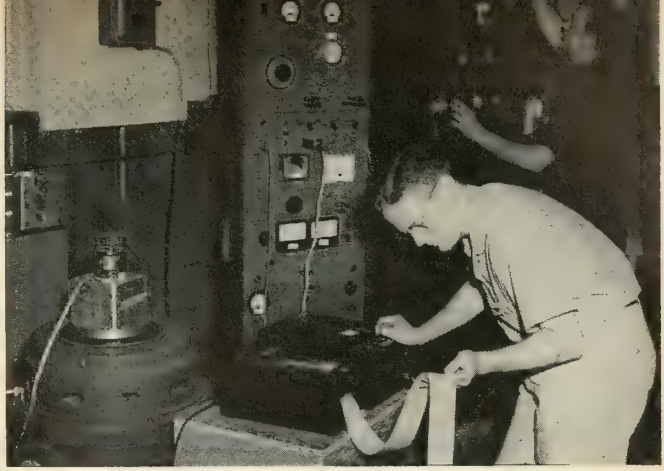
Birth of a Torpedo Gyro System





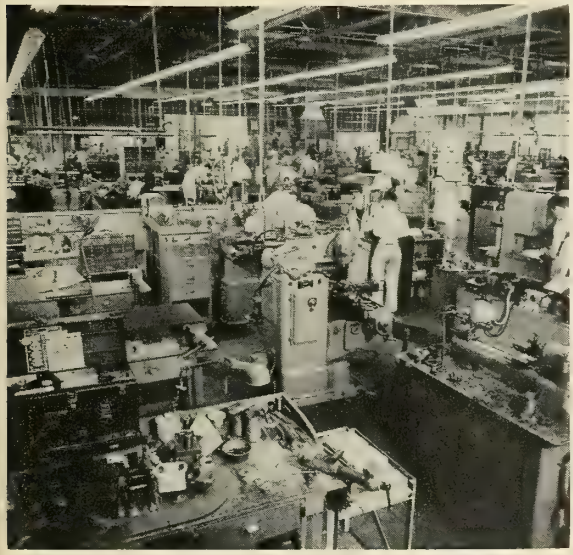
The torpedo gyro essentially serves a course control function and provides a safety measure against anti-circling to return. On the drawing table at Whittaker Gyro an experimental model is designed. From these specifications the prototype department builds component parts and tests them. When all components seem acceptable, a complete instrument is assembled and subjected to a thorough checkout. The new torpedo gyro now goes to the drafting table. The designers convert computations into a working design from which a prototype model will be built.





Following assembly the gyro is then sent to the test department. Specialized test equipment is needed to meet requirements and quality control measures. These include full function and environmental testing. Here, a test engineer subjects the course control gyro to high frequency vibration and acceleration tests.

To supplement the standard parts which are ordered from outside sources, the machine shop, shown here; turns out the precision components which are peculiar to this type of torpedo gyro.



The course control torpedo gyro is assembled in rigidly controlled atmosphere where temperature and humidity are constantly regulated. Any one entering the room must put on a nylon smock.





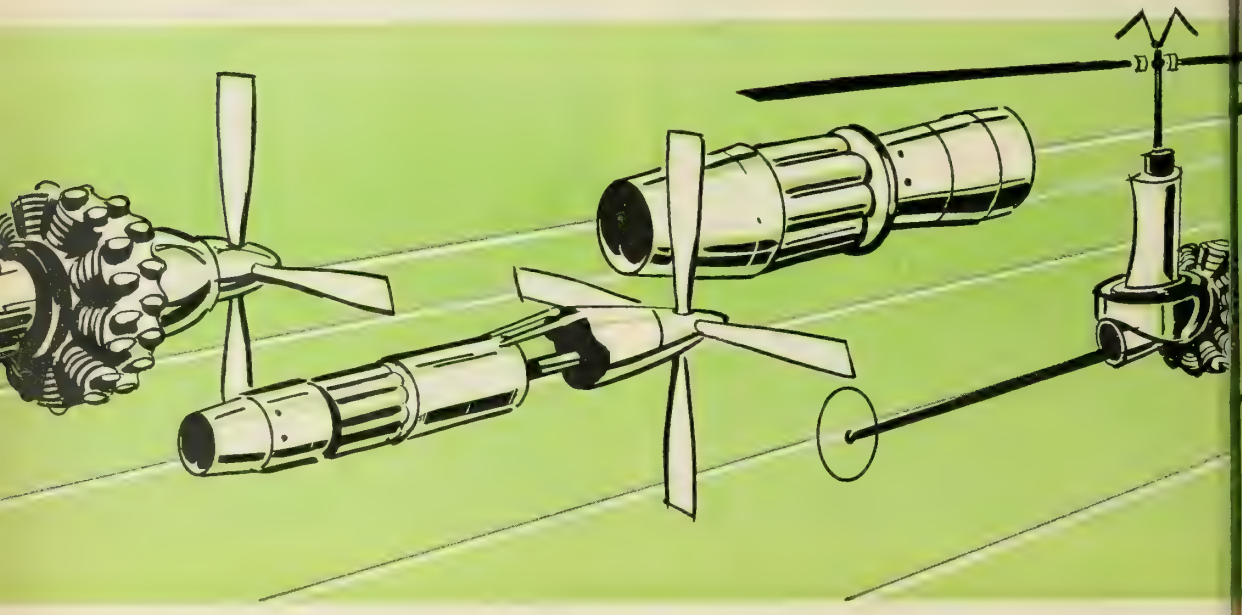
The gyro is packed and inspected, boxed and re-inspected before it goes into delivery channels. The magnitude of importance which this gyro will play in the guidance system of the modern day torpedo will justify the intricate preparation and care which follows each of these instruments to its destination.

SMALL JET ENGINES . . . CHAMPION WEIGHT LIFTERS

An entirely new family of aircraft will evolve from a new family of small lightweight jet engines now under development at the Fairchild Engine Division. These new powerplants will feature incredibly high thrusts and great lifting power...yet will be so light they can easily be carried by two men.

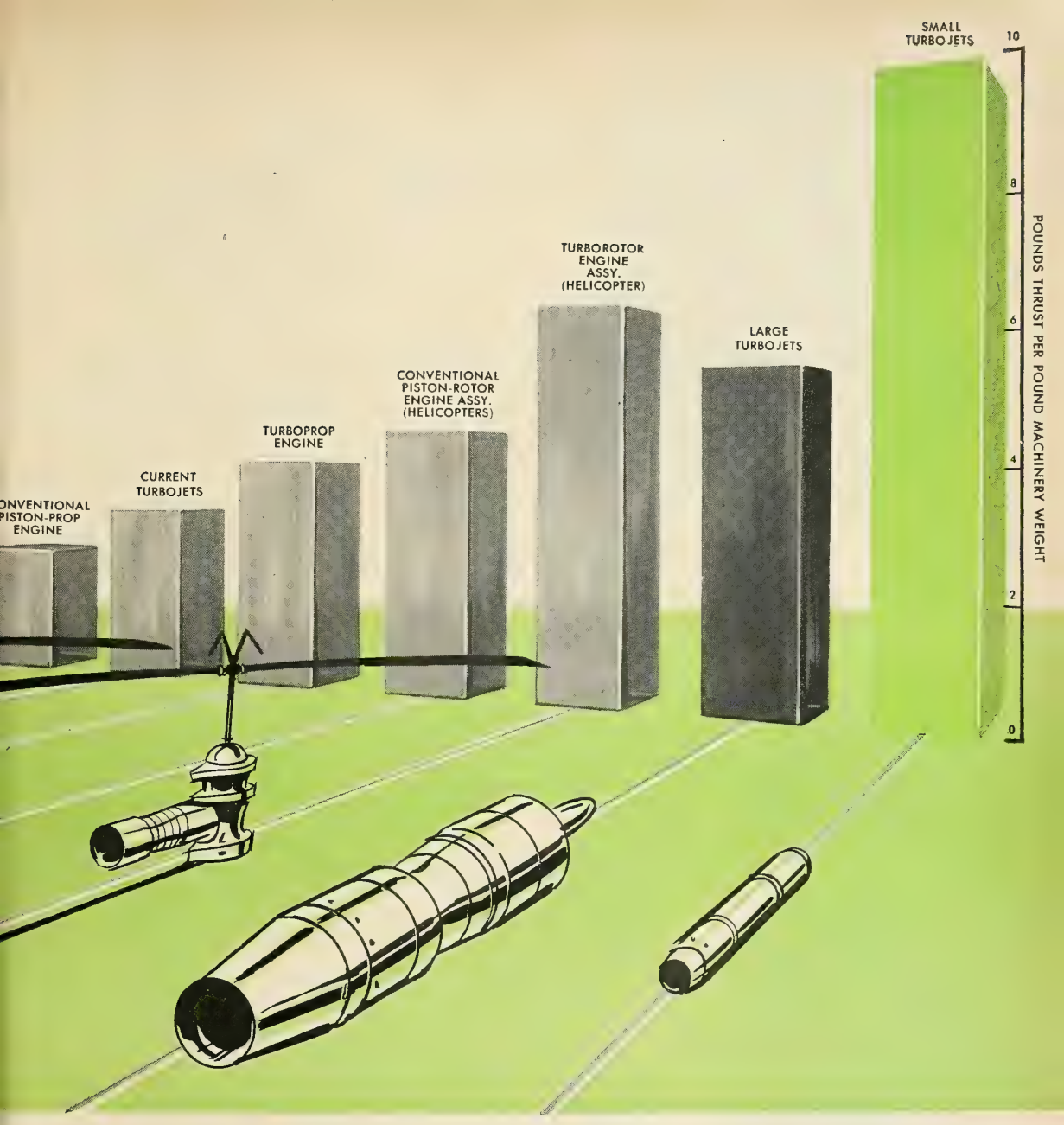
Highly compact, with low frontal areas, the small jet engines will deliver thrust/weight ratios starting at 8 to 1 with a long range potential of more than 10 to 1. They will be used in the high performance, lightweight trainers, interceptors, target drones, pilotless aircraft including missiles and intermediate class passenger and cargo jets of the nineteen sixties. They will also be used to power fighters and utility cargo craft, executive aircraft . . . and will make jet Short Take Off and Landing (STOL) and Vertical Take Off and Landing (VTOL) aircraft practical.

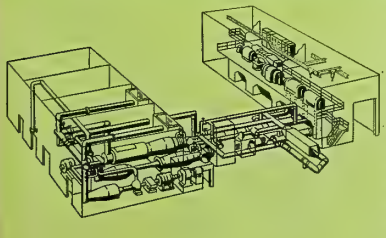
The small jet engine may be used singly, in pairs and in clusters. It provides multi-engine reliability in aircraft of a size now wholly dependent on a single engine. The small jet engine will produce greater versatility and utility in airplanes of tomorrow.



COMPARISON OF LIFTING CAPACITY OF POWER SYSTEMS

How the new family of Fairchild Small Jet Engines compare with other mechanical lifting systems.





The extensive research facilities at Fairchild Engine Division have been designed solely to test performance of the small jet engine. They range from full scale, high altitude test chambers to supersonic research for component design. Fairchild Engine Division has spent a decade in the design, development and production of small, powerful jet engines.

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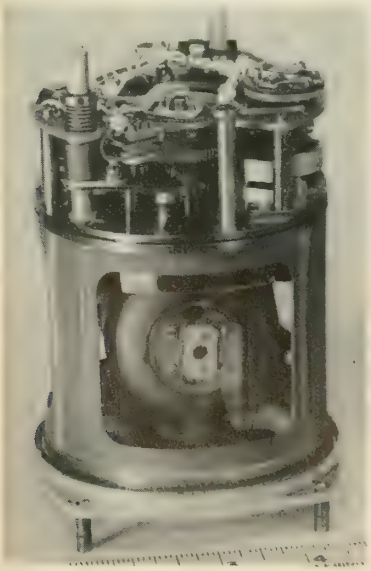
GYROS...
To Prevent Torpedo Vertigo

By Donald J. Rammage
Whittaker-Gyro

ONE OF THE MOST important advances in our country's weapon arsenal has been the development of the sonic homing torpedo. Although, the gyroscopic principle was involved in earlier torpedo experiments, it became increasingly important in sonic homing torpedo development where its role in the guidance system effected great changes.

Before the advent of the sonic homing torpedo which had its beginnings in World War I, the gyroscope was used to keep the torpedo on a straight course to the target. But it was costly to produce.

In spite of all efforts to increase the accuracy of the gyroscope and consequently the torpedo itself, the percentage of target hits was low. This was not due entirely to unreliability. The vessel under attack might spot the torpedo and take evasive action or it might be steering a zig zag course and change course after the torpedo had been fired. This demonstrated the need for a device to automatically cause the torpedo to home on the target.



Modern gyro for the sonic-homing torpedo. Small yet extremely reliable, Model 501705 is light and low in cost.

With the development of such a device, the gyroscope's role in the torpedo was immediately changed. It was no longer necessary to build extreme accuracy into the course control gyroscope. Most inaccuracies could now be overcome and corrected by the electronic sonic homing device.

While this would appear to give the gyroscope a back seat in torpedo guidance, it was found that it was still required. It was necessary to have a stable directional reference that would work in conjunction with the sonic homing device.

Before World War II the design, development and production of standard torpedoes was done largely by the Navy in its Ordnance plants. The all important directional gyro was also manufactured in the Ordnance plants. At the beginning of World War II, these plants were under terrific pressure to produce torpedoes in quantity under trying conditions.

Such programs were of high priority and there appeared little, if any, incentive for the development of the sonic homing torpedo. Up to this time, almost sole concern had been for torpedo accuracy as aimed and launched from a surface vessel or submarine. Our staggering losses during the war pointed up the need for a torpedo which could seek out submarines.

The experts at this point reached the conclusion that the homing torpedo had a multi-delivery capability—the same type torpedo could be launched from a ship, aircraft, blimp or a submerged submarine, seek out and kill with equal results.

It was decided early in the development that an electric drive would be required as well as non-cavitating propellers so that no tell-tale trail of bubbles would reveal position. To obtain counter propellant rotation (to keep the torpedo on a straight course) it was necessary that one set be driven with the shaft of the starter motor and the other set with the frame. This necessitated mounting the drive motor (automobile starter) with a set of bearings on the housing and bringing power to it through slip rugs. The need for electric power to drive the torpedo and operate its electronic equipment dictated the gyro's operation from an electric power source. Previously the gyros had to be air driven as this was the only power available in the torpedo.

At the stage of the hot-water-tank-and-breadboard-equipment no depth control mechanism was available although the feasibility of the sonic homing torpedo had been established. The development of this one remaining piece of equipment stood in the way of the entire program. Depth controllers were used on the standard torpedo but they were allowed high priority.

At this point fate intervened. One of the principal design engineers had undertaken some do-it-yourself hot water heating system repairs in his home. He was directly concerned with the controlled-submersion problem and this caused him to consider the principles of the pressure regulating mechanism. Here he found the device that was needed: essentially bellows and two electric mercury switches. He dismantled it from the heating system and a quick test in the following days proved its capability for the job.

While the development of the sonic homing torpedo proceeded, John James came to the Underwater Sound Laboratory at San Diego to assist in the development of a decoy-type torpedo. This device was to be launched from a ship being attacked by sonic homing torpedoes and by virtue of the quantity launched, undertake to decoy the sonic torpedo away from the ship.

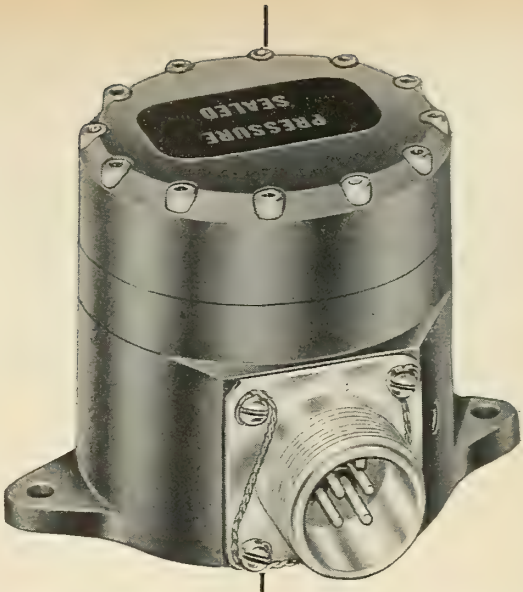
During the latter part of World War II, several other firms were working on development and improvement of the sonic homing torpedo. Among these were the Bell Telephone Laboratories with Western Electric Company as the production group.

Each group was working on a different torpedo for particular tac-

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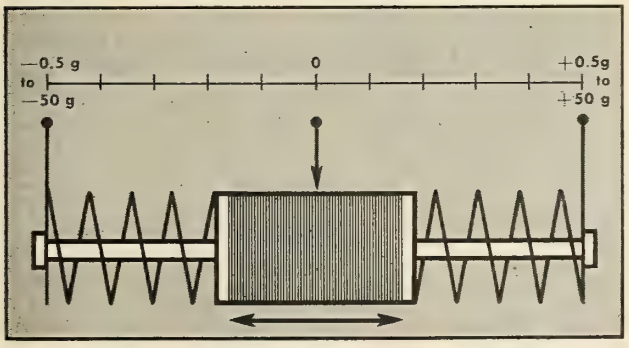
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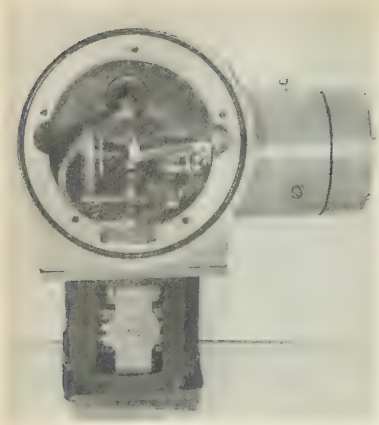


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Write for Bulletin LA



Mark 27 torpedo gyro. Accurate, predetermined course can be established by presetting the course-sensing element.

tical missions but all were using the sonic homing principle.

Whittaker Gyro with its work in the direct-current-powered gyro field was able to use basically similar gyro wheel and gimbal configurations and supply different sensing elements, caging mechanisms, case configurations.

The gyroscopes for the Mine Mark 30, the Mark 27 and the Mark 32 torpedoes contained gyroscopic elements modified from the roll control free and rate gyro and Air Force Type B-10 used in the *Azon* and *Razon* radio-controlled air-to-ground bombs.

The first sonic homing torpedos operated so that they homed on the noise generated by a ship's propellers and were primarily designed for use by submarines against surface ships.

The gyroscope for the Mark 27 was designed so that it could be given an initially determined course by presetting the sensing element before launching. The gyroscope was therefore designed so that the gyro's course-sensing element could be remotely set by means of a selsyn system operated from the fire control center.

The complete gyroscope package was mounted to the internal surface of the hull. By removal of a plate in the hull the gyro could be caged and an initial course set by hand into the gyro sensing element.

Once this was done the torpedo would then proceed along this predetermined course for a certain distance where the gyroscope would be electrically disconnected from the system and the sonic homing device would take over. It would become the controlling element for course control to the target or surface vessels.

At this point, it became apparent that the sonic homing torpedo required sound on which to home. It was obvious that the defense against such a weapon would be to stop the ship and shut down all power, cutting off all noise.

Another approach was to have the torpedo send out a sound wave and pick up the sound reflection from an object in the water. Thus a sound from the target would not be required. This approach was used in the Mark 32 which was produced by Philco.

This type of torpedo has a wider variety of applications than the basic sonic homing torpedo. It can be launched from ships, airplanes, surface vessels, blimps and helicopters. It does not need to be initially aimed. Once in the water it can look for a target.

For one such torpedo model a rate gyro was used for the course control. The rate of turning for the torpedo either to port or starboard had to be established. To accomplish this Whittaker designed a rate gyro with a sensing element consisting of switch contacts which would establish a turning rate.

The rate gyro portion of this instrument was given a new frame and sensing elements. With this type of gyro control, a search program can be established and the torpedo can continuously circle or proceed in any desired direction by means of a series of turns, first to port and then to starboard.

Another type of gyro, used to establish a search program, is a free gyro whose course-sensing device can be rotated by an electric motor which can be programmed. The programming can then cause the torpedo to circle in the direction desired or to proceed on a straight course until the torpedo hears the target. The sonic homing device overrides the gyro and directs the torpedo to the target. This gyro is used in the Mark 43 torpedo.

After World War II most development work on weapons was slowed down, the Korean War spirited production of the sonic homing torpedo. Whittaker Gyro found itself in the position of being unable to supply all the demands for gyroscopic instruments.

It was necessary as a compromise to furnish major gyro components to the government and prime contractors. They in turn completed the gyroscopes for use in the sonic torpedos.

In the years between World War II and the Korean conflict, major developments had been made in the manufacture of gyroscopic instruments and as soon as it was possible, Whittaker Gyro undertook the development of a gyroscope especially designed for use in sonic homing torpedos. Up to this time the gyros this company turned out for the various torpedo programs had been modified types originally developed 10 years earlier.

It was thought by many of the torpedo manufacturers that because of the decreased accuracy requirements of the gyro for sonic homing torpedoes they could be made at extremely low costs. However, this was not the case.

It was found that many of the torpedoes were used in applications where the torpedo and gyroscope were subjected to high shocks, high sustained accelerations, high vibration, wide trying tension temperature variations and other extreme environmental conditions. Further, small size and light weight were more in demand.

The design of the gyroscope for the modern sonic homing torpedo must take into consideration many factors in addition to basic sensing accuracy. These include the tactical mission of the torpedo, the environment conditions to which the gyro will be subjected both during its final mission and en route to its final mission. It must have exceptional reliability and lastly be of small size, light weight and low cost.

To design a gyro, taking these factors into consideration and weighing each one in relation to cost, has required extensive research including the evaluation of many design approaches and countless tests.

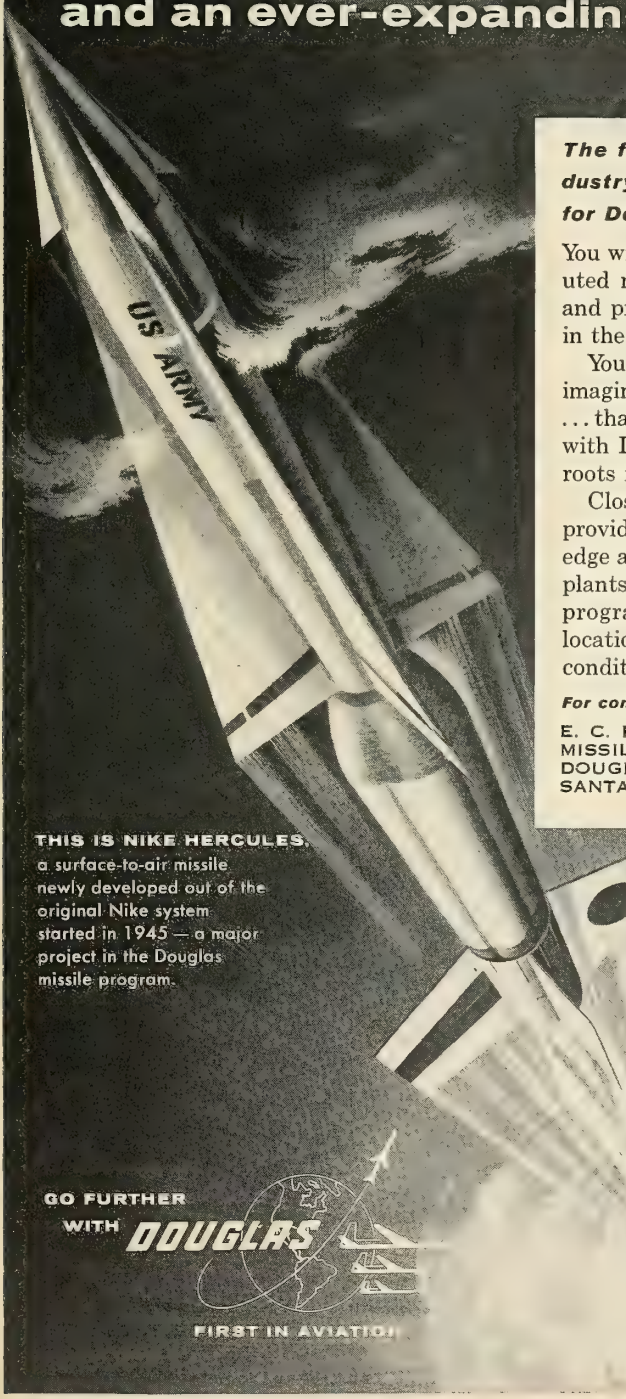
The culmination of the research and development has resulted in the production of the Whittaker Model No. 501705 gyro. This instrument incorporates many innovations such as monel gimbals which derive their strength from the use of spherical and cylindrical shapes. This has allowed the use of thin sections which reduce the weight of the components to little more than if made from aluminum.

The use of monel has eliminated the need for corrosion protection on the major parts. The use of monel has also eliminated one of the major problems created by wide changes in operating temperatures.

The coefficient of expansion of motor shafts, gimbals, and frames are now made of materials which essentially have the same coefficient of expansion thus maintaining dimensional tolerances between major components. This prevents creation of damaging forces on the bearings or the creation of too great clearance between parts which could cause unbalance. Major components have been designed for fabrication by punch press and screw machining.★

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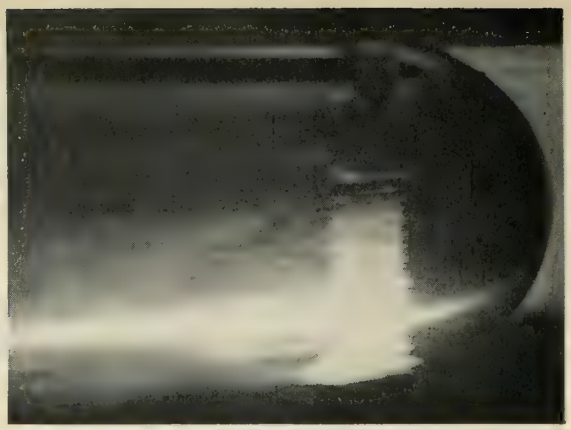
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Cavitation—an equivalent of aerodynamic turbulent flow—troubles both ends of a torpedo. Fig. 1 shows propeller turbulence; Fig. 2, cavitation at the nose cone.

HYDRODYNAMICS
The Art of Silence

by Prof. George F. Wislicenus
State University of Pennsylvania

THE TORPEDO is a submerged body kept suspended in its medium primarily by its buoyancy, and is therefore hydrodynamically a first cousin to the rigid air ship or "dirigible" rather than to airplanes.

Considering the well advertised advances in the torpedo's most important target, the submarine, it can be taken for granted that demands for increased speeds will be ever-present. Considering that the density of water is about 900 times that of air at moderate altitudes, this isn't going to be easy.

From the point of view of drag the classical torpedo speed of 45 knots may be regarded as equivalent to airplane speeds in the neighborhood of 950 knots.

Since the velocity of sound in water is of the order of 4000 feet per sec. It is immediately evident that the "Mach numbers" of the bodies travelling at foreseeable speeds under water are very low compared with all airplane speeds now in use.

There exists however, in hydrodynamics a phenomenon quite analogous to the compressibility or Mach-number effects in gases which becomes effective, and is indeed of decisive importance, within the speed ranges of torpedoes as well as submarines.

The hydrodynamic phenomenon that plays the same speed-limiting role in connection with liquids as "Mach-number effects" in the field of gas dynamics, is known as cavitation. Cavitation is defined as the local vaporization of a liquid in motion, caused by local pressure reductions resulting from the dynamic actions of the liquid.

These local cavitation voids have a detrimental effect on the overall efficiency of the device. Cavitation also causes mechanical damage, but most importantly, it is noisy. The very onset or "inception" of cavitation, barely visible to the eye under favorable test conditions, has been found to be acoustically as harmful as more extensive cavitation. This interferes with sonar-directed torpedoes.

The parts of torpedoes most susceptible to cavitation are the propeller blades since, by virtue of their helical (screw-like) motion, these blades cut through the water at a higher speed than the torpedo itself. Aeronautical airfoil data apply directly to these most critical parts of a torpedo.

The local pressure reduction is usually expressed as a certain fraction of the "stagnation pressure" $PV^2/_2$. This fraction (Cp) is called the "minimum pressure coefficient." It can be derived directly from airfoil data pertaining to "critical" flow conditions with respect to locally sonic flow. The range of favorable i.e. low values of Cp is smaller the thinner the airfoil.

On the other hand thin airfoils are necessary if low values of Cp are required. This simply means that the more refined the design to meet increased demands of good cavitation performance, the greater will be its sensitivity to departures from design operating conditions.

The practical significance of the pressure coefficients, given for example in Fig. 3, is illustrated in Fig. 4 by applying these data to the blades of a torpedo propeller. It was assumed that the peripheral velocity of the propeller is twice as great as the forward velocity of the torpedo so that the velocity of flow relative to the blades is $\sqrt{5}$ times the forward velocity (v) of the torpedo and its propeller. (This assumption corresponds to an "advanced ratio" $J=V/n \circ$ of 1.57) Fig. 4 gives the velocity of advance as a function of the depth of submergence for two different blade pressure coefficients (cp) as may be derived from Fig. 3. It is seen, for example, that a speed of 40 knots would demand for cavitation-free operation a submergence of over 50 ft. provided the thinnest blade section listed in Fig. 3 (6% thick) is used having a pressure coefficient of about 0.25. It should be noted that such a thin blade section will have such a low pressure coefficient only if the flow meets the blade within slightly less than ± ½ degree of the design angle of attack. This illustrates the precision with which design conditions must be met to avoid cavitation under actual operation.

It is also evident from Fig. 4 that with a higher blade pressure coefficient,

say 0.50, as may be expected with blades of about 12% thickness, cavitation-free performance can be expected only at moderate speeds or very great depths of submergence. This explains why hydrodynamic propellers have usually rather thin blade profiles.

The sensitivity of a high-quality propeller, explained in the preceding section, makes it clear that cavitation-free operation may be difficult if not impossible to achieve on the basis of theoretical design procedures only.

Prior to field testing it is desirable to determine the hydrodynamic performance characteristics of a new torpedo under the controlled conditions of the laboratory. The "Towing Tank" has been successfully applied to the development of torpedoes.

For more detailed observation, particularly regarding the location of incipient cavitation, the Navy's Bureau of Ordnance has built a large Water Tunnel at the Pennsylvania State University.

The most important test variable with respect to cavitation is, of course, the pressure which can be changed over a wide range without affecting other test conditions.

It should be recognized that the simple description of the cavitation phenomenon given above is far from complete. It is not at all evident why cavitation should take place exactly at the vapor pressure of the liquid as measured under certain standardized and steady laboratory conditions.

Considering, for example, that cavitation might be expected to start with microsopically small bubbles, it is somewhat surprising to find that the surface tension of these bubbles apparently does not play a clearly definable role in cavitation inception.

Another problem is the possibility of scale effects in testing, whereas, pressure coefficient is a ratio of two pressures and as such is independent of absolute dimensions or of velocities, the question must be answered whether there are perhaps significant "scale effects" present when applying the test results obtained at one scale and velocity to another scale and velocity.

There are several other problems in the field of cavitation that are urgently in need of rational answers. For example, the effects of accidental departures of blade or body contours from their ideal design forms, such as surface roughnesses, certainly deserve careful attention, as such departures are in practice not to be avoided.

Another problem that still awaits a practical solution is that of the interaction between stationary control surfaces and rotating propeller blades.

Cavitation is by no means the only hydrodynamic problem. Hydrodynamic stability and control of the submerged body is of decisive importance, the more so since target seeking torpedoes must meet higher demands with respect to maneuverability than the old, straight-running weapons.

The towing tank as well as the water tunnel are available to test torpedo bodies under various inclinations against the direction of the flow and with various deflections of its control surfaces. Means for measuring the forces acting on the body under these operating conditions are available or under development.

It may be surprising that the problem of hydrodynamic efficiency has hardly been mentioned in this article. Today well designed torpedoes are hydrodynamically so efficient that no advancements in this respect are to be expected without correspondingly major developments in the control of the flow processes that are responsible for the hydrodynamic behavior and resistance of submerged bodies.

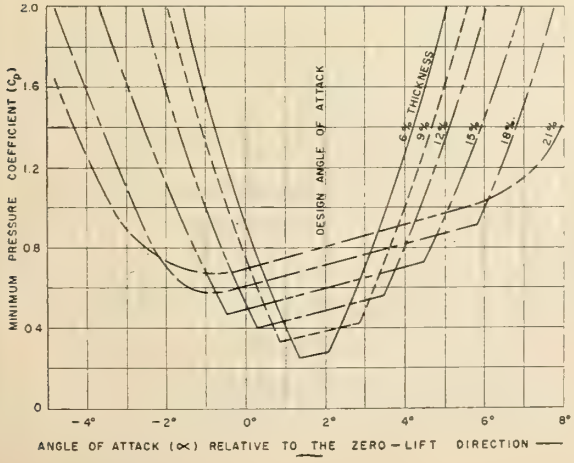
The question has frequently been raised whether certain kinds of nature's best swimmers, such as the porpoise or the barracuda, suffer none of the torpedo's limitations.

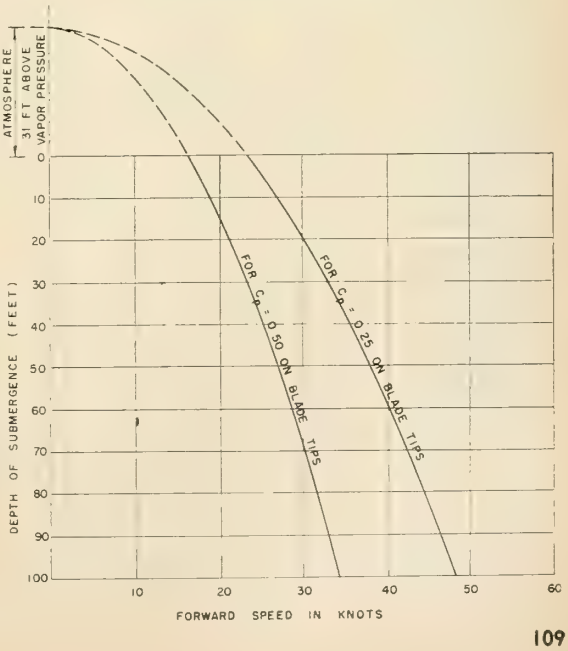
The only clearly foreseeable reason why such fish may have an appreciably higher hydrodynamic efficiency than torpedoes is the possibility of maintaining "laminar" flow over the entire body, which is certainly not true for torpedoes. The problem of maintaining laminar flow in the bounder layer of torpedoes has been much studied.

Laminar flow airfoils have been tested and found to perform in accordance with the theoretical predictions provided one is able to maintain an extraordinarily high quality of surface finish. Particles as small as small flies sticking to the surface of the wing were found to bring on turbulent flow.

Therefore the practicability of achieving such advances under actual operating conditions is as yet highly questionable. It is thus evident that far-reaching advances in the hydrodynamic efficiency of torpedoes will demand more than modern fluid mechanics can readily offer at the present time. In this respect the torpedo engineer is fighting on the very forefront of this broad field of applied science.★

Immediately below (in Fig. 3) is a plotting of the minimum pressure coefficients for a typical series of modern NACA airfoils (NACA Rpt. 824). These data are almost directly applicable to hydrodynamic phenomena. To the right (in Fig. 4) it is applied to torpedo propeller blades for which the peripheral velocity of the propeller is twice as great as the forward velocity of the torpedo so that the flow relative to the blades is $\sqrt{5}$ times the forward velocity of the torpedo.

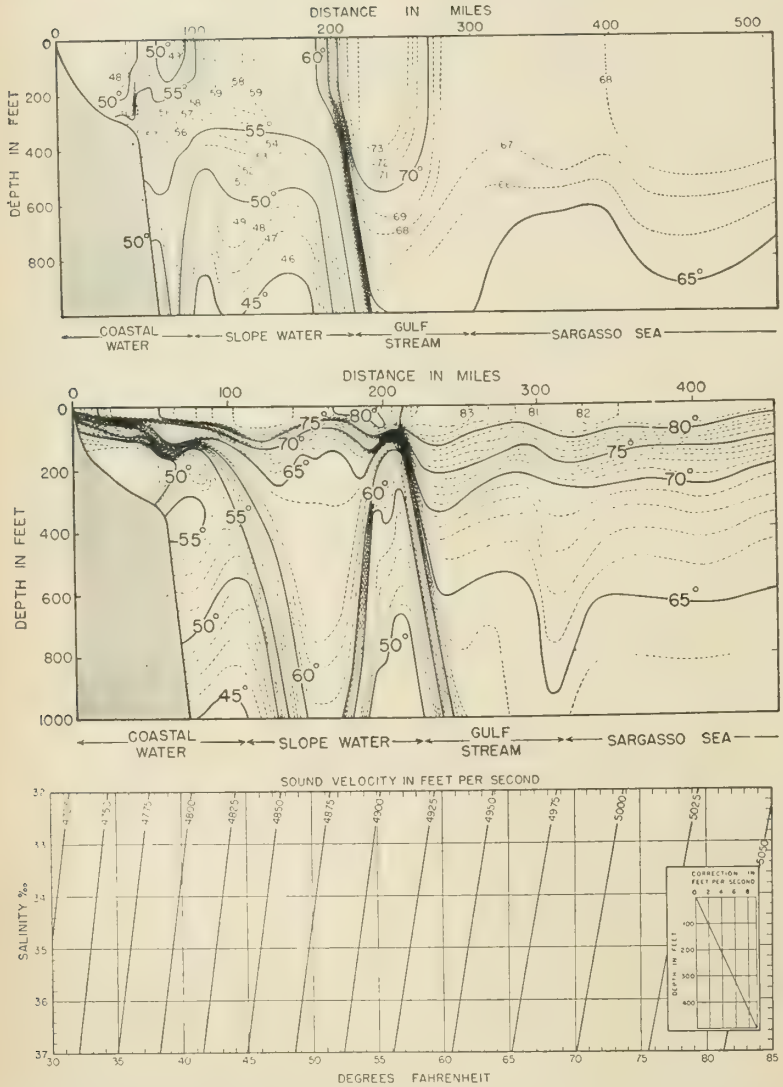




A Realm that Needs Only More Understanding

the OCEAN

By Seabrook Hull



Top diagram shows a temperature profile southeast from Montauk Point in midwinter. Below is a salinity profile taken simultaneously. Bottom chart shows how sound velocity varies with temperature and salinity, including depth correction. Changes take place daily and seasonally.

PURE WATER is a wonderful thing. In the metric system, at least, many of its constants are unity—one calorie of heat raises one gram (or one cubic centimeter) of water one degree centigrade. As a medium it's constant and reliable, and all of its properties are well known. To the laboratory chemist, it's tool, reference and standard medium.

But take 1,370,323,000 cubic meters of the stuff and dump it on an oblate sphere some 8000 miles in diameter so that it fills the valleys, ravines and low-lying plains until it covers nearly three quarters of the surface of that sphere to a mean depth of 3795 meters. Set the sphere spinning on a cocked axis at a rate of 15° of arc per hour, and orbit it in an ellipse around an immense white-hot sphere. Now load this nice simple chemical, water, with a heavy concentration of a miscellaneous mixture of salts. Envelop it in a thick layer of gas. Endow it with the greatest known concentration and variety of biological life. The one-time chemist's friend gains a new name—the ocean—and becomes the missile-man's nightmare.

As an environment for manned and unmanned vehicles the ocean has both desirable and hair-raising characteristics. But like space, it's a coming medium for man's endeavors, both military and peaceful. This article aims at providing missilemen of all types with a primer on its nature and properties. To cover it well took H. U. Sverdrup, M. W. Johnson and R. H. Fleming over 1000 pages in their book, "The Oceans." And even they will admit that the sea volumes of the world constitute one of the greatest unknowns known to men.

The major difference between the air and the oceans is biological life. Floating plants and small floating animals in the upper couple of hundred

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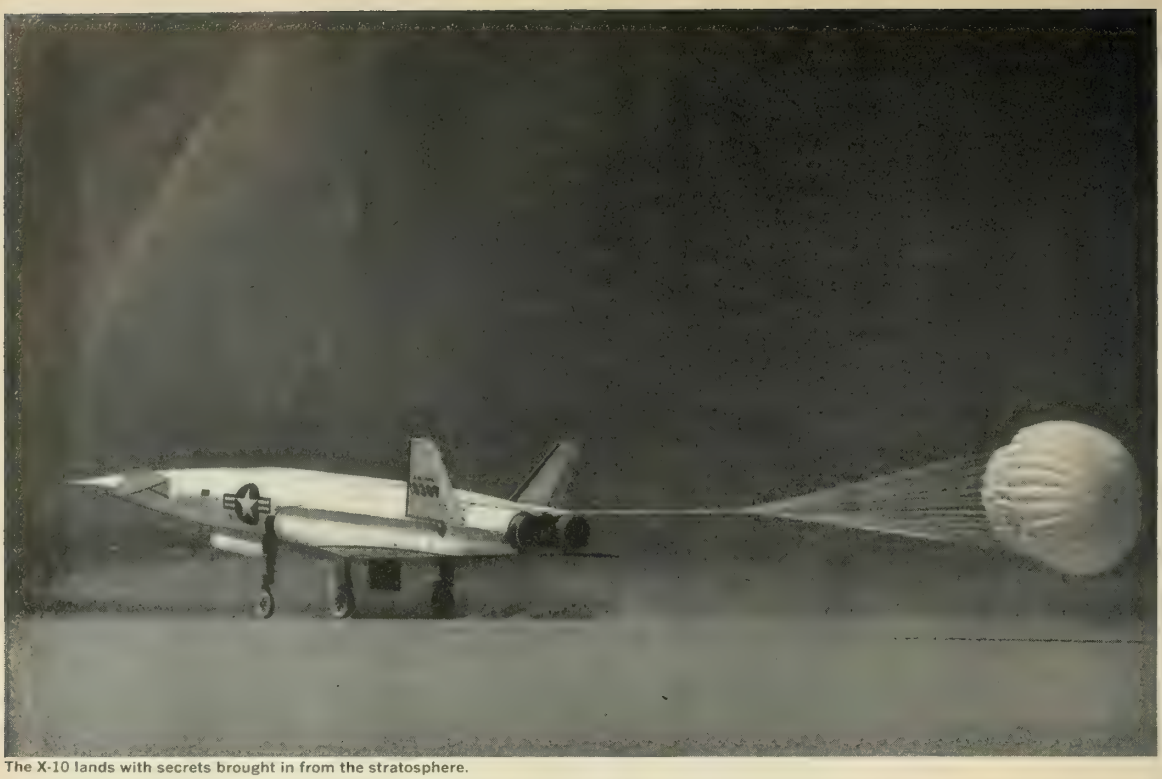
This section of California has a colorful and romantic past. Nearby are graceful missions built by the Spanish padres nearly two hundred years ago. Among the mountains are deserted mines and "ghost towns" recalling the era of the gold rush. The test site itself has yielded the remains of an Indian settlement. This is the land that knew such men as Kit Carson and John C. Frémont.

Great men of the past depended on vision, daring, and leadership to accomplish their goals. Grand Central is using these same principles in the greatest adventure of our time — the conquest of outer space.

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MISSILE DEVELOPMENT DIVISION

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Torpedo fired to simulate aerial launch at Naval Ordnance Test Station, Inyokern, Calif., cavitates and porpoises clear of the water and almost 90° off course. This sort of thing is one of the biggest problems in underwater missile design; is a big reason why more study of the ocean and fish is needed.

meters are so dense sometimes that they record on depth meters with the strength of a solid floor. Bigger swimmers—blue whales get over 100 feet in length; weigh up to 150 tons—live both both near the surface and at great depths. Those animals that spend all of their time in the dense black world several thousand feet below the ocean's surface are all mouth and stomach.

The deepest man has ever been in the ocean is 14,000 feet in a free, self-propelling device similar to a small submarine and known as a bathescape. Probably no submarines have ever been below 1000 feet and survived—their normal maximum operating depth being on the order of 500 feet.

The ocean covers 71 per cent of the earth's surface. It is a three dimensional medium, with mean depths in the Atlantic Ocean of 3926 meters; in the Pacific, 4282 meters; and in the Indian, 3963 meters. The Mindenao trench in the Western Pacific is 10,500 meters with an ambient pressure of 16,000 pounds per square inch. It's the deepest known.

The ocean is similar to the atmosphere in that: it is continually in motion (the jet stream is analogous to the Gulf stream); it has permanent current features; there are oceanic fronts, sharp thermal gradients over short distances; whereas in the atmosphere there are altitude layers known as the troposphere, tropopause and stratosphere, in the ocean (going down) there are the troposphere, thermocline and stratosphere; the two mediums have similar and common boundaries—the earth's surface and each other. Phenomena, in general however, are slower in the ocean than in the air.

The differences in the earth's two major fluid environments are mainly dependent on the fact that one is a gas and one a liquid. Ocean has many properties similar to water, but it is the presence of salt that makes the ocean what it is. Its major properties are a function of: temperatures ranging from —2° to 30° pressure, from zero to 10,000 db (a decibar equals 1.5 psi, one tenth atmosphere, and is the pressure increase per meter of depth); and salinity, 33 to 40 per cent.

Some physical properties of water are unique and apply generally to the ocean. Heat capacity, latent heat of fusion, latent heat of evaporation, surface tension, dielectric constant and heat conductivity of pure water are the highest for any fluid. However, the dielectric constant of sea water, because of dissolved salts, is obviously relatively low. Water also has good transparency and good dissolving power.

Circulation affects a number of the ocean's properties to a considerable degree, such as the distribution and concentration of suspended matter, chemical contents, organisms, transparency, eddy diffusivity, conductivity, etc. Independent of motion are: specific heat, osmotic pressure and density.

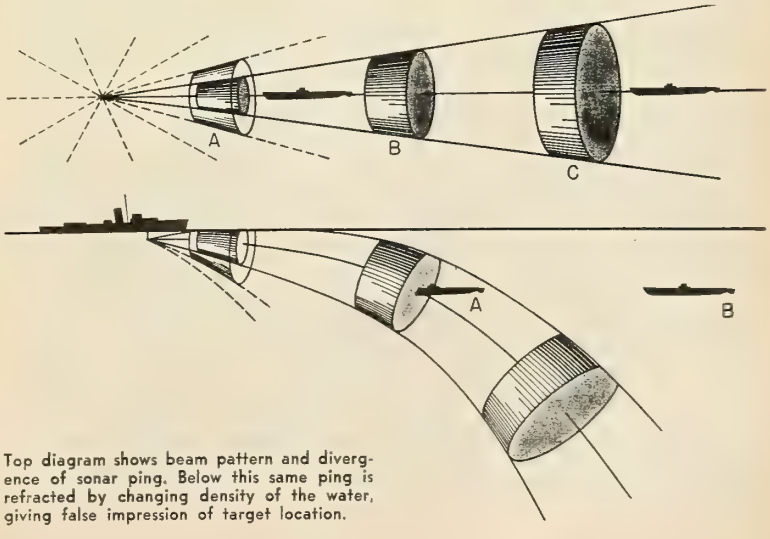
Electromagetic energy, generally speaking, finds the ocean is not its medium, though the strength of the earth's magnetic field remains unaltered. Infrared rays are 99 per cent in less than a meter. Of all electromagnetic energy most is reflected; the rest is quickly absorbed, with blues and yellows penetrating the deepest. These have been detected down to about 1000 feet.

The acoustic properties of the ocean are relatively good, being a function of temperature, pressure and salinity. Thermal radiation is poor due to high heat capacity and low thermal conductivity.

In terms of weapons systems, efficiency of radar is poor (to a point of complete uselessness); propulsion is relatively poor; acoustic devices work well; blast transmissibility is excellent; so is concealment, if silence is maintained.

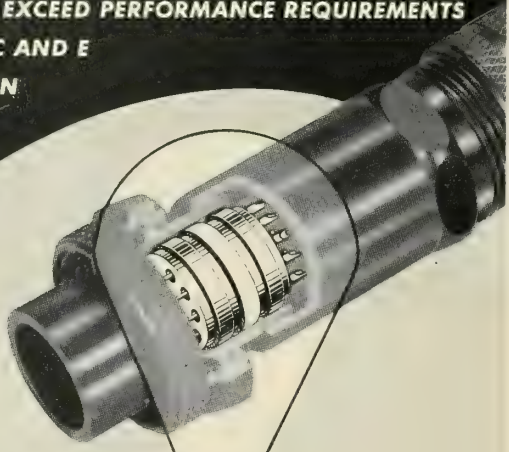
Elsewhere in this issue, hydrodynamics is called the art of silence. The first effort of every submarine and underwater missile designer is to get greater performance with no noise. The characteristics of water that result in noise generally also retard speed, increase drag. The biggest of these is cavitation—a pecularity of a fluid.

A break-away of the medium from the surface of a body passing through the medium occurs when the pressure drops below the vapor pressure of the medium. In simple terms bubbles appear on the skin. Not only do they

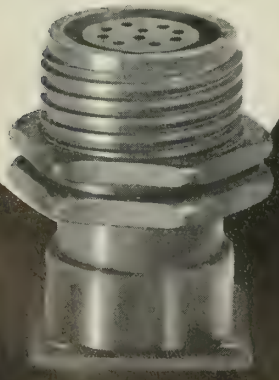


Top diagram shows beam pattern and divergence of sonar ping. Below this same ping is refracted by changing density of the water, giving false impression of target location.

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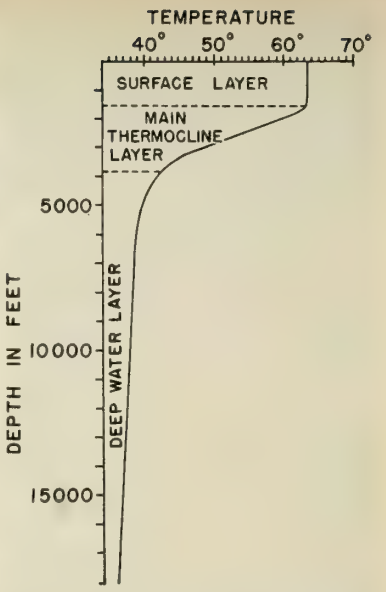


Chart of basic thermal structure of the ocean (typical midwinter conditions in mid-latitudes) shows sharply changing temperature.

reduce the efficiency of a propeller, for example, but when they collapse they do so explosively and make a racket. This phenomenon is basically similar to going from laminar to turbulent boundary layers in aeronautics. Perhaps the biggest underwater design objective is the development of high-speed, cavitation-free underwater flight.

But man isn't the only one to make noise underwater. Fish and their other underwater cousins are quite a vocal lot, and the noise they make doesn't help man's effort to detect, guide and communicate acoustically.

The speed at which sound travels underwater depends mainly on the water's density. This varies primarily with temperature and salinity. The variations are many, local and changing. Sound refracts in changing density. Thus, a target may appear to be in one direction but may actually be in another. These are just a few of the problems facing underwater missile designers.

Yet nature appears to have few of these problems. Fish swim at high speeds and don't cavitate. They travel great distances without any navigation problems. They maneuver rapidly and intricately en masse in complete unison, obviously having a highly efficient communications system all their own. The south Atlantic's diving petrel literally flies into the water and continues to fly underwater with his wings with complete ease—transitional missilemen take note!

So, that these things are possible is, in a way, proven. It only remains for man to discover the way.★

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FICo engineers and produces the guidance for the Redstone Missile.
U.S. Army Photo



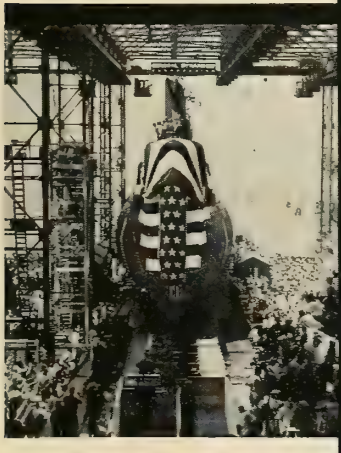
FICo navigational equipment goes into a wide range of aircraft.
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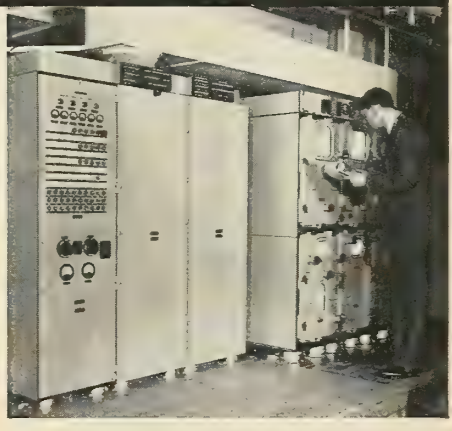
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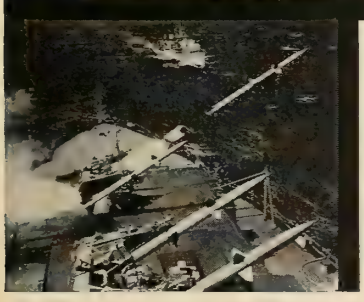
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FICo research and design led to improved safety and arming device for Army atomic cannon.
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FICo launching and control order computers are used for Navy A-A missiles.—*U.S. Navy Photo*

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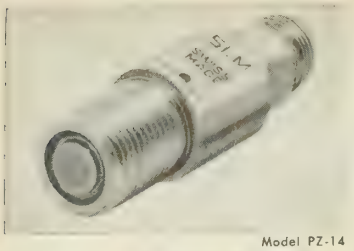
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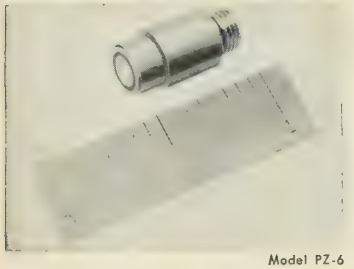
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Space Medicine

by Hubertus Strughold, M. D.

For the first time, *space medicine* appears as a topic in the columns of m/r. *Space medicine* is a branch or an extension of *aviation medicine* which started some forty years ago. *Aviation medicine,* now an officially recognized specialty of medicine—studies the human factors involved in atmospheric flight. In contrast, *space medicine* studies the human factors in flights outside the atmosphere or in space flight.

From a medical point of view, outside the atmosphere is considered beyond the functional borders of the atmosphere which are found in the upper atmosphere and some even within the stratosphere. The cessation of the various atmospheric functions indicate that the larger portion of the atmosphere is partially or totally *space equivalent.*

The concepts of the atmosphere's functional borders and space equivalence within the atmosphere, both developed in *space medicine,* have removed the fictional connotation from space flight and have brought it to a down-to-earth reality. Therefore, *space medicine* studies not only the human factors involved in satellite flight, lunar operations, and interplanetary space travel, it concentrates its special attention upon *space equivalent* flight operations. The record flight of Capt. Iven C. Kincheloe in October 1956 was a space equivalent flight—to a very high degree.

Scope of *space medicine* also includes the study of ecological conditions on other planets, particularly atmospheric conditions. This field is called planetary ecology or more generally, *astrobiology.*

In 1949 Maj. Gen. Harry G. Armstrong created the Department of Space Medicine at the School of Aviation Medicine USAF, Randolph Air Force Base, Tex., to study the human factors involved in space flight.

At about the same time the Aeromedical Laboratory at Wright-Patterson AFB, Ohio, began preparations for animal studies in rockets. Since 1952 the Air Force has had a Space Biological Branch at the Aeromedical Field Laboratory at Holloman Air Force Base.

A decisive start into future human space flight was made in 1951 at the Symposium on the Physics and Medicine of the Upper Atmosphere, in San Antonio, Tex. The symposium was organized by Maj. Gen. Otis O. Benson, Commandant of the U.S.A.F's School of Aviation Medicine at Randolph Air Force Base, Tex. and Clayton S. White, M. D., Research Director of the Lovelace Foundation, Albuquerque, N. M.

At the 1951 annual meeting of the Aeromedical Association, a space medicine branch was founded. Each year it offers a special session at these meetings. Many space medicine meetings have been held since.

By action of the Board of Directors of the American Rocket Society, at its 1957 Spring Meeting, a new technical division was created, known as the Human Factors Division. Included in its purlieu are *space medicine* and *human engineering.*

It is apparent the field of *space medicine* is off to a solid start and an unlimited future.

Next meeting is the Symposium on the "The Age of Space," sponsored by the Southern Research Institute, Birmingham, Ala. It will feature a visit on May 16-17 to the Redstone Arsenal at Huntsville, Alabama. *Space medicine* will be the subject of the paper by the Surgeon General of the United States Air Force, Maj. Gen. Dan C. Ogle.

This and other *space medicine* conferences will receive thorough coverage by m/r in general and in this column in particular.

international briefs

Russians Set Up Czech Missile Bases

The Soviet Union has established eight missile launching bases in Czechoslovakia according to the London Daily Telegraph.

One base is near Olomouc, Moravia. North of the Olsany Highway, an area of 500 acres has been enclosed since October. There are other sites about 10 miles west and slightly south of Zwittau, at Valasske Klobouky in Western Slovakia, near Tabor, and southwest of Strakonice. These have been completed.

Three other bases are understood to be under construction. One is 10 miles east of Pilsen, another 30 miles almost directly south of it, and a third slightly west of Litomerice.

The Litomerice site is reported to have been planned for eight rocket launchers. It is the largest.

The others appear to be about half the size. All the sites have their own anti-aircraft defense, radar installations and flight strips in the vicinity.

In none has rocket launching equipment yet been installed. But more than a dozen mobile air defense rocket launchers have already been shipped from Russia into Czchoslovakia.

It is believed that the rockets, or other missiles, for which the sites are designed will have ranges of 120, 360 and 480 miles and will be able to reach into West Germany, Austria and Italy.

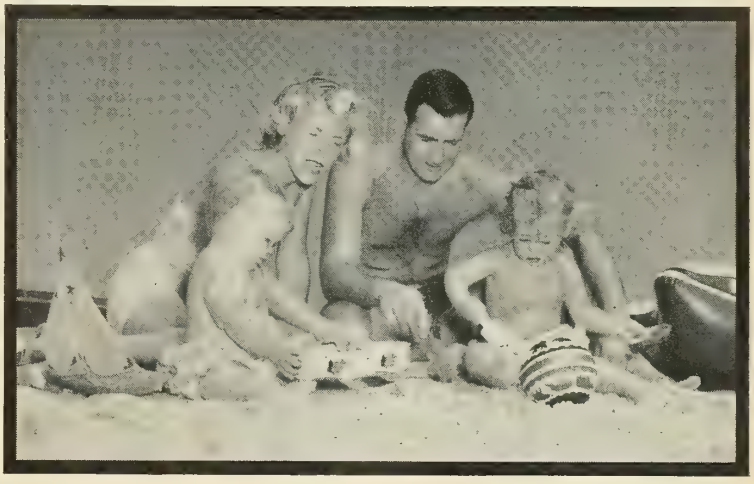
It is reliably reported that in Smichov, southwest of Prague, a Russian training school for rocket technique has been established. It is said to be headed by Lt.-Gen. Pomarev, a Russian technical expert.

Swedes Get *Jindivik* Missile

First deliveries of a batch of Australian-built *Jindivik* pilotless target airplanes have been made to the Royal Swedish Air Force. The *Jindivik* will be used in Sweden for missile firing tests. It is considered by Swedish experts as the best design now available for this purpose. Sweden is understood to have bought ten *Jindiviks* at a cost of $1,200,000 as an initial order. Meanwhile, at the end of last month the Swedish Navy announced that it has fired the first Swedish naval missile—from the destroyer *Halland*. It will be used for naval artillery purposes.

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World Astronautics

By Frederick C. Durant III

In Germany the world's first rocket society came into being thirty years ago. In less than fifteen years rocket technology evolved from an art to a practical science. The A-4 (or V-2) still stands as a monument to ingenuity and determination.

In early post war years strong anti-militaristic feeling dominated all activities of the reborn society, Gesellschaft für Weltraumforschung. However, the society kept abreast technically with rocket developments abroad and extrapolated data for ambitious space flight programs.

Recently, the society has been renamed: Deutsche Gesellschaft für Raketentechnik und Raumfahrt to indicate increased interest in rocket technology. In addition to their journal, WELTRAUMFAHRT, members will receive a new technical journal to be published entitled: RAKETENTECHNIK UND RAUMFAHRTFORSCHUNG. For those rocket engineers and laymen who read German, membership is a bargain; about $6.25.

In Bremen, the Arbeitsgemeinschaft für Raketentechnik is designing, in addition to the "oil-spray" rockets (m/r April '57, pg. 88), a static test stand, a liquid propellant motor, a hybrid (solid-liquid) motor and an inexpensive multi-staged sounding rocket.

In Stuttgart, Dr. Ing. Eugen Sänger and his mathematician wife, Dr. Irène Sänger-Bredt, head a small study group at the Forschungsinstitut für Physik der Strahlantriebe e.V. Stuttgart which has developed a hot-water RATO unit. But the major production of the FPS has been outstanding papers in ramjet combustion equilibria calculations and ultra-advanced treatises on atomic and photonic rockets. The Sängers, it will be remembered, authored the famous hypersonic rocket-powered globe-circling "skip-bomber" study in 1944.

At a number of universities excellent graduate and post graduate research is being carried out in a number of related fields. Some of this work is under USAF contract.

In the background, reported only through rumor, are indications of interest by the Army and industry. There is natural hesitation but short range anti-tank and anti-aircraft missiles are considered a safe bet to be under development.

•

Twelve official station sites have been picked by the Smithsonian Astrophysical Observatory for optical tracking of the earth satellites. Only two of the sites are on U.S. soil (White Sands Proving Ground and West Palm Beach). Surprisingly, just one of these stations is to be shared jointly with the official NRL Minitrack program; this site is in Australia.

The first station to be ready will be at White Sands this August. The next will be the important one in South Africa which will first see the satellite appearing out of the northeast from Florida about 30 minutes after launching. The rest of the stations will be activated every 2—4 weeks as the specially designed super-Schmidt cameras and crystal clocks are delivered and checked out. Station operators will be trained at White Sands. It is expected that with good weather, the optical tracking stations will be kept busy throughout the IGY. The Minitrack stations will have little to do after the two-week—duration batteries in the satellites have ended their transmissions.

•

In a radio interview broadcast beamed at Western Europe, Russian scientist Anatoly Blagonravov has concluded that man will suffer no physical consequences from flight into space. These conclusions were based upon data from six years of experimentation with dogs carried aloft in sounding rockets.

COCKTAILS FOR ROCKETS

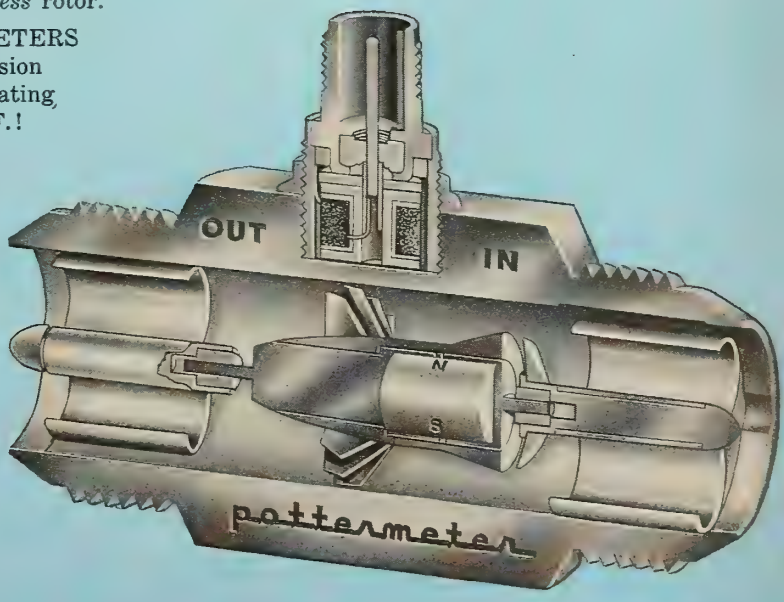
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The Johns Hopkins University
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International Scene



By Anthony Vandyk

The long-awaited confirmation has come that guided weapons are being included in the U.S. mutual aid program for the NATO nations in fiscal 1957. The missiles include the *Honest John* and *Matador* SSMs and the *Nike* SAM. These three models are already being used by U.S. forces in Europe. Which European nations will get which missiles and when? There has been no official answer but Dutch War Minister Staf stated last month that the *Honest John* is to be supplied to the Dutch Army and that personnel would soon go to Germany for training. The *Honest John* will replace the army's heavy artillery.

•

Britain's *Sea Slug* naval SAM now in the test stage is being built by two components of the giant Hawker Siddeley Group—Sir W. G. Armstrong Whitworth Aircraft Ltd., and Armstrong Siddeley Motors Ltd. Armstrong Whitworth is responsible for the airframe while Armstrong Siddeley is producing the rocket engine for the missile. The guidance system comes from a company outside the group, the General Electric Co. which has no connection whatsoever with the U.S. firm of that name.

•

Australia's first SAM unit will be established, Prime Minister Menzies disclosed at the same time as he announced the alignment of his nation's armaments with those of the U.S. Mobile control and reporting units will be established at Darwin and Perth, he revealed. An Australian defense mission will visit Washington in a few weeks to seek details of available short and medium-range missiles. It may also discuss the use by the U.S. of Australia's Woomera range for testing long-range American missiles.

•

British counterpart of North American's Santa Susana, Calif. rocket testing facility is an establishment in the north of England at Spadeadam, Cumberland. This desolately located test facility is being operated by Rolls-Royce Ltd. under contract to the Ministry of Supply. The engines to be tested there will be North American rocket units built under license by Rolls-Royce.

•

The Canadian government's guided missile program was the subject of brief baiting in the House of Commons recently. Opposition members asked Defense Minister Campney if any guided missiles "apart from the obsolete *Sparrow*" were to be made available to Canada by the U.S. He indicated that this was the case. There has been no official word from the Canadian government on the companies participating in the *Sparrow* license program, although Avro Aircraft and Canadair have both been given contracts for the development of a missiles system.

•

The de Havilland export organization is working on a program to enable the various DH companies to conserve the important position they have won since the war in the military export field. Much of de Havilland's bread and butter has come from the export of the Vampire, both the fighter and trainer versions, which is powered by a "house product"—the DH Goblin engine. It is hoped to replace Vampire exports with overseas sales of the highly efficient DH AAM which uses an infra-red guidance system developed by Mullard, British affiliate of the giant Dutch Philips electronics group.



Photo courtesy American Gyro Corporation

How to keep a missile on target

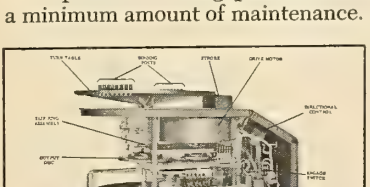
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Underwater Missile and Torpedo TEST EVALUATION

by Gilbert L. Maton
John I. Thompson & Co.

THE DETERMINATION of whether a developmental weapon possesses the required operational characteristics needed is largely based on evidence resulting from test. The fundamental procedure is to subject the proposed design to as rigorous a test program as possible. The results of this testing are then carefully scrutinized and appraised in light of tactical adequacy and technical practicality to determine whether the design is adequate, needs work, or is impractical.

Since the decision established from such evaluation is based on test data, it is intuitively apparent that the data accumulated from such testing must be reliable and useful. To best illustrate how this may be accomplished, it will help to review the scientific method or general experimental procedure which can be recognized as intrinsic to any test program. This method delineates that the planning and conduct of any experimentation follows a set step-by-step plan.

(1) A clear and unambiguous statement of the objective of the test is made.
(2) All available background information regarding the item to be tested is assembled and scrutinized.
(3) The specific test program is carefully planned.
(4) The test program is executed.
(5) The resulting data is assembled and analyzed.
(6) The analytical results are interpreted.
(7) The conclusions are reported.

In order to bring the importance of each step of this procedure into proper perspective, each of these steps and its specific application to torpedo testing and evaluation is discussed in some detail in the following paragraphs.

Test Objectives

A clear statement of the objective of the test in advance serves two purposes; (1) it defines the scope of the program and makes subsequent planning administratively practical, and (2) it meets the requirement of a valid conclusion that the objective be stated without reference to the result.

The general objective of an underwater missile and torpedo test is largely influenced by the development stage of the weapon. The evolution of the weapons system can be divided into distinct phases: Formulative; Planning; Research; Experimental; Design, Production Engineering; Pilot Production; Full Production.

The formulative phase is devoted to establishing the operational requirements of the weapon. As a background, it is probable that the requirements arise from the planning and operating elements of the military service. Occassionally they may come from a technical agency or laboratory in which a well known operational problem is examined from the viewpoint of a specialized science. In any case, these requirements represent the basic purpose and need for an improved weapon.

The planning phase is used to establish the objectives of the program in light of time and economic considerations. The organizational structure is delineated and the basic scope of the program is outlined. It is mainly an administrative control period.

The research phase is concerned with "filling in gaps" in existing fields of knowledge. In general, it is a measurements program of experimental elements and components having unknown features in order to determine the practicality of meeting the operational requirements of the weapon. The measurements program is planned and scheduled to support the selection of specific design parameters which are incorporated into a design specification.

The experimental phase is the most complex and critical in the developmental program. It is mainly concerned with demonstrating the workability or sufficiency of a proposed design. The consecutive steps of this phase may be outlined as follows:

(1) Integration of the design by sketch
(2) Layouts (on paper)
(3) Details (on paper)
(4) Parts fabrication
(5) Assembly and adjustment of parts
(6) Adjustment of assembly and corrections
(7) Tentative investigation and dynamic tests

The design phase of the program consists of the same general steps as the experimental phase. The purpose of this phase is to provide a number of similar models for use in the rigorous technical evaluation which concludes the phase. This evaluation is a dynamic test which subjects the "service test" models to realistic exercises which closely duplicate the requirements imposed by the operational application of the weapon rather than to any arbitrary or indirect standards of a laboratory.

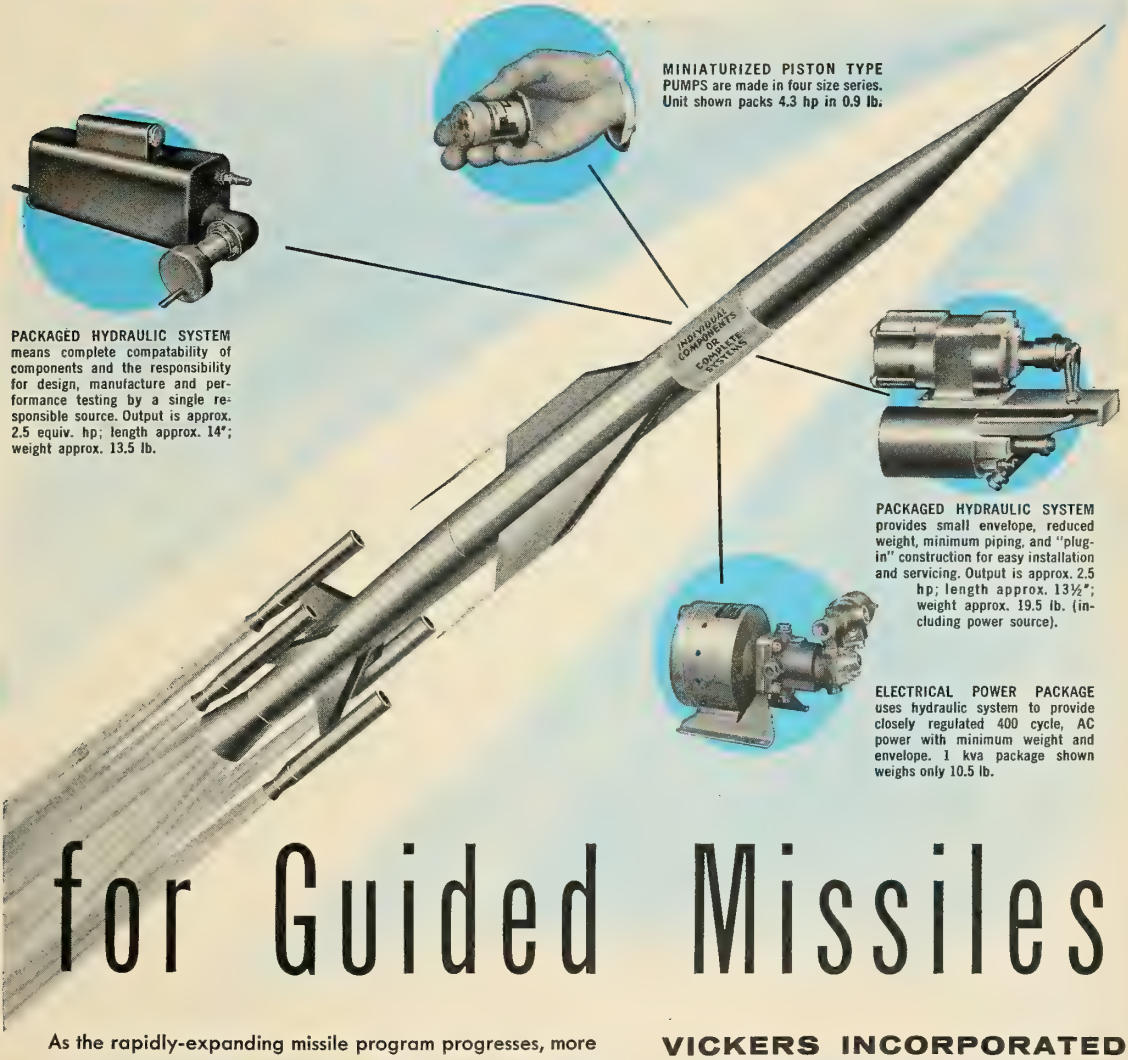
It is not unusual for the first few steps of this phase to be repeated many times. Eventually, however, a number of supposedly identical units, or service test models, are available for technical evaluation.

The production engineering phase may be combined in some cases with the design phase previously described. However, scrutiny of the program will invariably enable them to be differentiated. In a sense it is an analytical phase, since it is mainly concerned with analyzing *if* and *how* manufacturing operations influence the design. Three viewpoints are involved, with the designer, the manufacturer, and the military service (user) each contributing a facet to the analysis.

A developmental production lot of the item is manufactured in accordance with preliminary production techniques, and using preliminary tools, jigs, and fixtures. These developmental models are used in product demonstration tests and operational evaluation tests. The former determines if production tech-

The author has drawn freely on the substance of reports prepared under U.S. Navy Bureau of Ordnance contracts with John I. Thompson & Co. for studies, design of experiments, and evaluation of developmental torpedo testing. Procedures outlined are the author's own, however, and may not be construed as constituting the Bureau's official procedures.

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niques have affected performance in any way; the latter ascertains the operational characteristics of the weapon and represents the final test action of the phase.

The pilot production phase is devoted to smoothing out any remaining production problems. A prototype production lot is manufactured at this time, and these prototype models are used for familiarization and type tests. In addition, the preliminary proofing procedures for production lot units are determined and documented.

The full production phase is concerned with the quantity production of the design in its final form. The manufacture and all detailed steps of assembly and inspection are dictated by the outcome of all previous evaluations and uses of the weapon.

The chart illustrates this fundamental phase concept of a developmental program by outlining the general configuration of developmental effort previously discussed.

Although conscious separation of phases is shown with a constant progress in one direction, phase combinations and reversals must be appropriately considered in actual cases. It must also be recognized that the degree of overlap between phases may vary. This imbrication is more noticeable in cases where the ultimate manufacturer is chosen at the start of the development.

Of the phases discussed, the research, experimental, design, and production engineering phases are of primary interest because they represent the main portion of the developmental program in which some manner of physical testing of the proposed weapon is done. The general test objective of each of these phases may be defined as follows:

Research:

To determine if the basic design idea shows promise as a solution to the operational requirement.

Experimental:

To determine if the design idea can be incorporated into a device to fill the technical requirements.

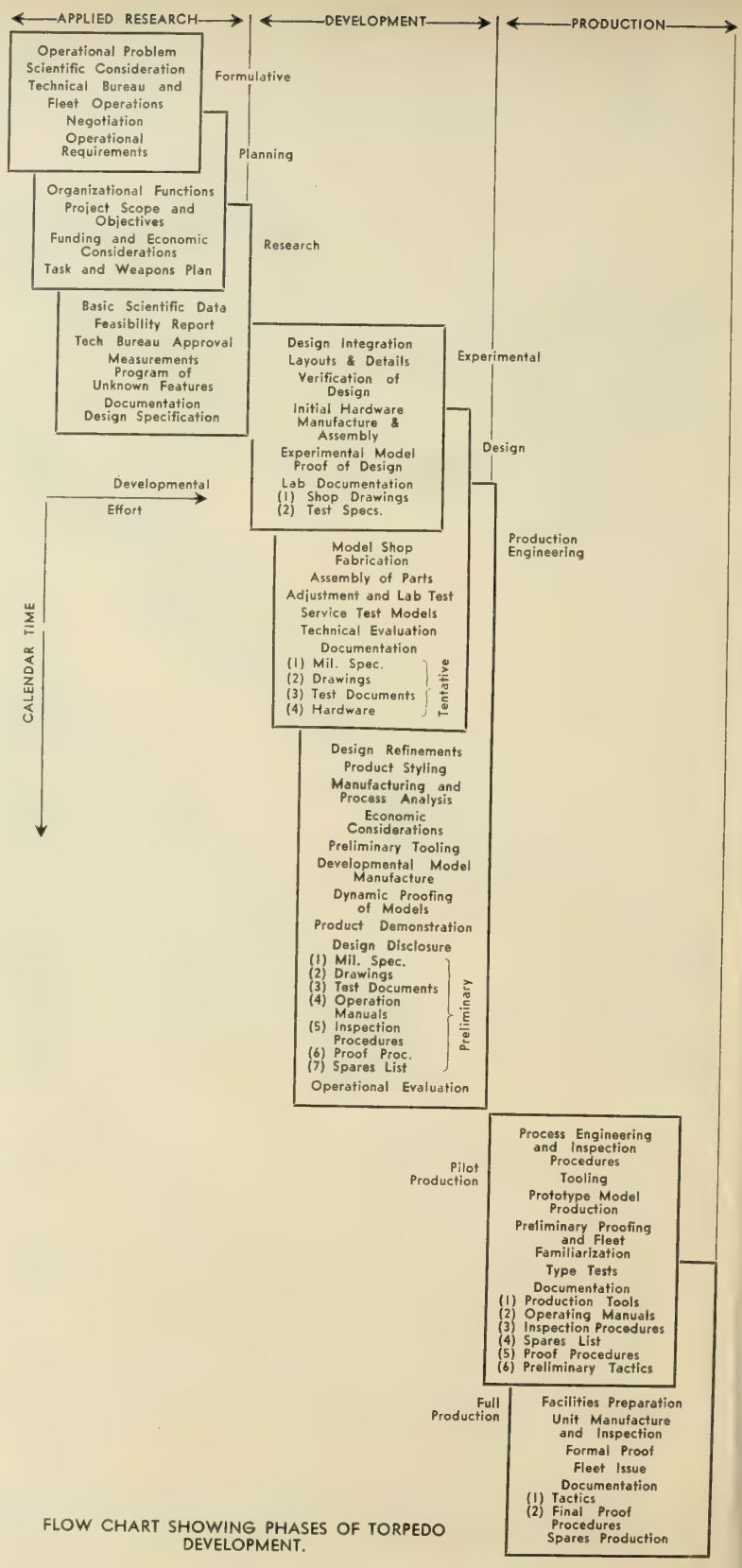
Design:

To determine if the mechanically (technically) configured design will provide a satisfactory solution to the operational requirements.

Production Engineering:

To determine the compatibility of the design to manufacturing techniques and to establish the basic operational characteristics of the design.

A sound scientific approach to a test calls for the general objective to be more explicitly delineated than outlined in the preceding paragraph. If this is not done, analyzing personnel may be confronted with the task of determining



FLOW CHART SHOWING PHASES OF TORPEDO DEVELOPMENT.

from the test criteria just what the original test objectives were. In view of the extremely high cost of developmental testing and the possible universal expenditure of the test units it is apparent that the omission of this initial consideration can seriously jeopardize the success of any test program.

Test Background Information

This step in experimental procedure involves collecting all existing information relating to the test objective from the best available sources. Tabulation of pertinent data from earlier testing work on the item has three specific advantages:

(1) It avoids the necessity of repeating work previously done

(2) It increases the certainty with which the new test may be planned and may reduce substantially the work required to disclose new facts

(3) It reduces the tendency to take calculated risks in the planning which would be based on engineering intuition rather than known facts.

During development, nearly every torpedo produced is in several ways different from torpedoes of the same group. Most units assembled in the experimental and design phases are handmade by highly trained engineers and technicians. Each man concerned in the fabrication of a model is, by his training and experience, competent to devise appropriate functional tests to check and adjust the assembly after each step in the construction of the unit. These tests are seldom written, and two equally competent men are not likely to devise and perform tests which are identical in conduct or precision. Since the tests and adjustments are often duplicated by different men and frequently at entirely different activities, it is desirable—even necessary—from the standpoint of getting useful and comparable data for analysis to document and standardize such test procedures as early as possible.

The test design step involves planning of specific details of the program in light of the test objectives. As such, it is concerned with the planning, control, conduct, analysis, and interpretive aspects of the test, rather than the specific test origin alone. In a broad sense, this step is the most crucial of those in the testing procedure since the selection of a test design imposes a selection of the possible methods of analyzing the results, and this, in turn, dictates the entire interpretive function.

The planning of a specific test design consists of four basic steps:

(1) Compilation of all test variables

(2) Compilation of all test criteria

(3) Experimental test design in preliminary form

(4) Review and revision of the design in light of analytical techniques and possible results.

Test variables are all the environmental and operational factors which might possibly affect the test results, including factors which can be controlled and those which cannot. Test criteria are the data which translate general test objectives into objectives involving measurable quantities. This requires that the background information of the weapon be analyzed to determine which parameters can most validly provide data which will verify the test objectives.

The experimental design, itself, incorporates the test criteria with particular selections of the controllable operating and environmental factors into a comprehensive test. A multitude of possible combinations of factors and criteria is possible, but a single "optimum" design is generally not possible for at least three reasons: (1) the analytical problem posed may be extremely complex; (2) the complete solution may involve parameters which are not economically measurable; and (3) the time to formulate and determine the "optimum" design is not always available.

The most practical approach to the test design problem is to select an experimental design from a family of "good" ones; that is, designs which have desirable characteristics with respect to the particular test. One such class of designs has been given the name "factoral" designs. A second class is "latin square" designs. Such general designs must be examined to establish specific applicability to the test under consideration and the class exhibiting the most favorable characteristics selected.

Test Conduct

This step of scientific testing procedure requires little explanation. It should be emphasized, though, that an orderly and conservative approach is essential. This especially applies to the taking of measurements and collecting of data where every precaution must be taken to assure that valid, unbiased, and accurate results are obtained. These precautions may be most properly assured if a systematic and inclusive schedule, spelling out clearly each test step to be followed, is prepared prior to conducting the test.

Test Reports

This step of the testing procedure requires that the test performed be described clearly and with full explanation of the background and pertinence of the problem and the meaning of the results. In all testing work, whatever the details of the method, it is essential that another person or activity be able to repeat the test and check what has been done or observed. Despite the authority or convictions upon which they rest, conclusions are of questionable value unless they can be verified.

Although much could be said concerning specific report content and arrangement, it seems sufficient to say that report preparation should be viewed in terms of three objectives:

(1) Conclusions should be limited to an objective summary of the evidence so the work recommends itself for prompt consideration and action.

(2) Sufficient information should be supplied to permit the reader to verify the results and draw his own conclusions.

(3) Data should be presented in good form for future use.

All testing and evaluation reports should follow the same general form, tailored to the particular needs.

Test Data Analysis

This step in procedure represents the reduction of the recorded data into numerical form and application of proper mathematical and statistical techniques to the results. As mentioned previously, this step is not really a separate consideration, since it is so largely simultaneous to the test design step. Selection of test design imposes a selection of methods of analyzing the test results. It has been found that when a test program is run before the question of analyzing the results is examined, the result invariably is a low efficiency in information per observation.

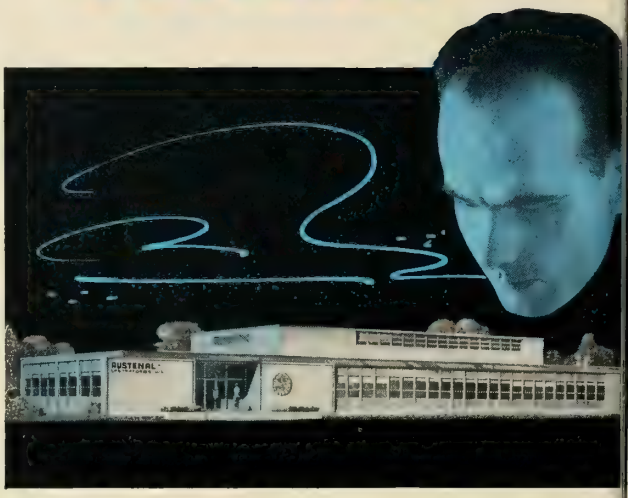
Experience has also proven that the statistical approach to test design and test analysis is highly rewarding. This is particularly true in dynamic torpedo exercises where random variations in performance are of comparable magnitude to the effects to be established by a change in system parameter. In these cases, *statistical methods offer the only sound and logical means of analysis; there is no question of any alternative which is equally satisfactory.*

Test Result Interpretation

This step concerns correlating test results with initial test objectives. It cannot be too strongly emphasized that any numerical analysis of test data is only a convenient way of detecting and separating the effects of varied factors. The process of interpreting the results, that is, of telling administrative and management personnel what conclusions can be drawn or what should be done next, is by no means automatic. The process requires that personnel who interpret the statistical computations have a thorough knowledge of mathematical techniques and a clear understanding of the technical and tactical aspects of the weapon.★

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Torpedo Terms and Terminology

Underwater Missile Glossary

THE RAPID PROGRESS of torpedo development in recent years has brought with it a flood of terms. In many cases differentiation in the meanings has not been clear: different terms were found to have identical definitions; terms were so specialized that they had little general usefulness in torpedo development and evaluation programs; or a single term might be used to denote two or more different things. Up to this time, there has been no common basis for terms used.

The Bureau of Ordnance felt that because the program was carried out by many separate facilities and contractors, standard language would improve the ease and accuracy with which torpedo information could be exchanged.

In compiling a glossary of torpedo terms, John I. Thompson & Co., under the auspices of BuOrd, reviewed more than 100 reports and applicable documents. This material reviewed covered almost all current advance undersea-weapons programs, as well as some of the related science of guided missiles. The following is a digest of this glossary.

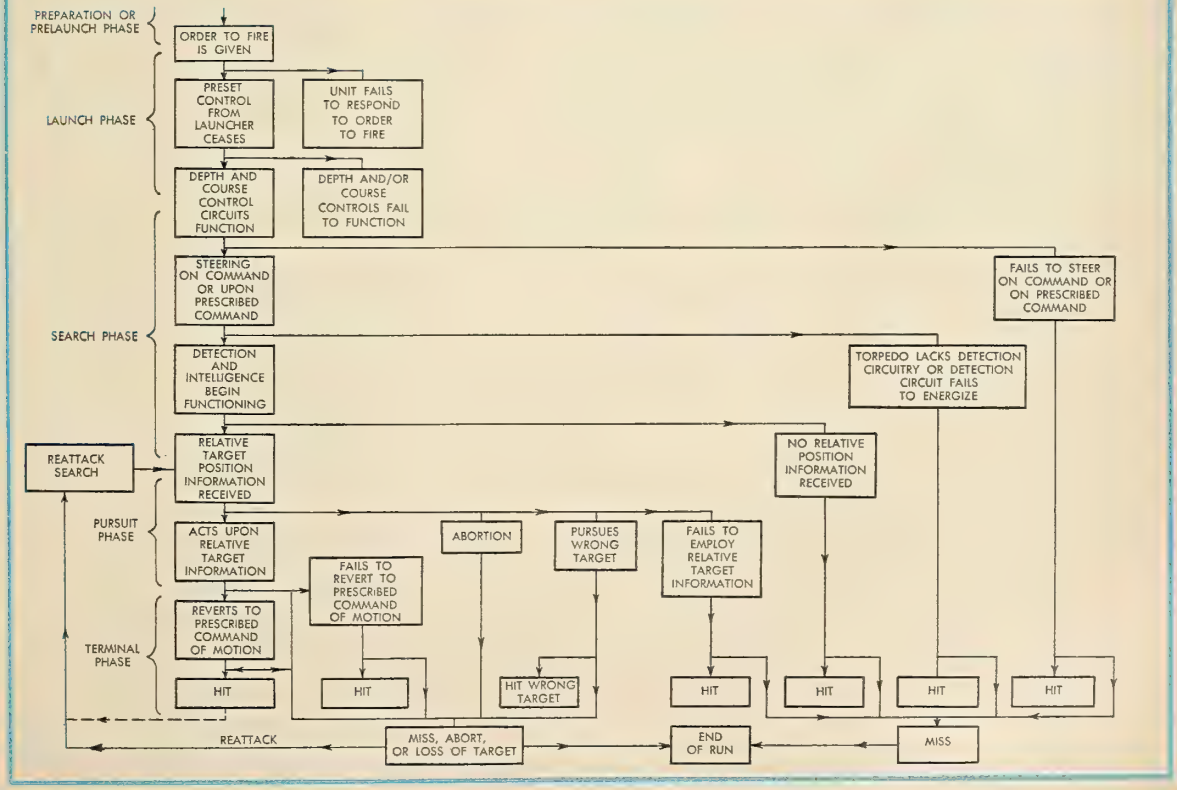
Two types of terms normally associated with *time* in a torpedo exercise are (1) terms that define the unique *instant* of a specific action or event and (2) terms that refer to the *interval,* or period, of time between two such actions. The latter terms are, of course, dictated by and subordinate to the former.

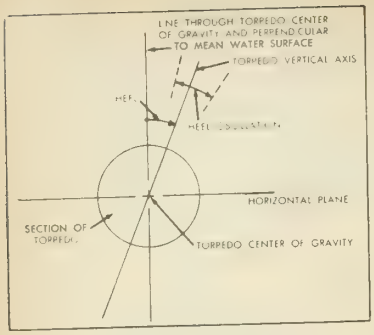
The sequential history of a general torpedo run divides logically into at least six distinct phases: (1) the preparation phase, (2) the launch phase, (3) the search phase, (4) the adquisitive phase, (5) the pursuit phase, (6) the terminal phase. A seventh phase, reattack, may exist under certain circumstances and for certain torpedoes.

The simplest torpedo has depth and direction (gyro) senses. The more complex torpedo can sense in some manner the presence of the target. A basic analysis of these relationships should be made in terms of the relatively new science of cybernetics. Such an analysis was beyond the scope of the present compilation.

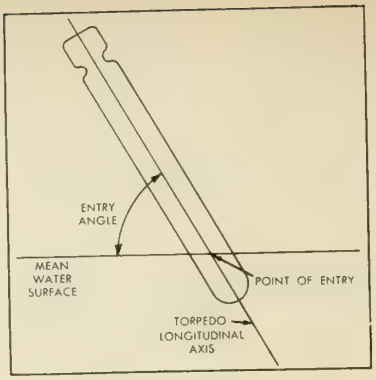
The study on which this glossary is based discovered that terms currently used to describe the intelligence

Diagram of phases and actions of the torpedo run, arranged chronologically.

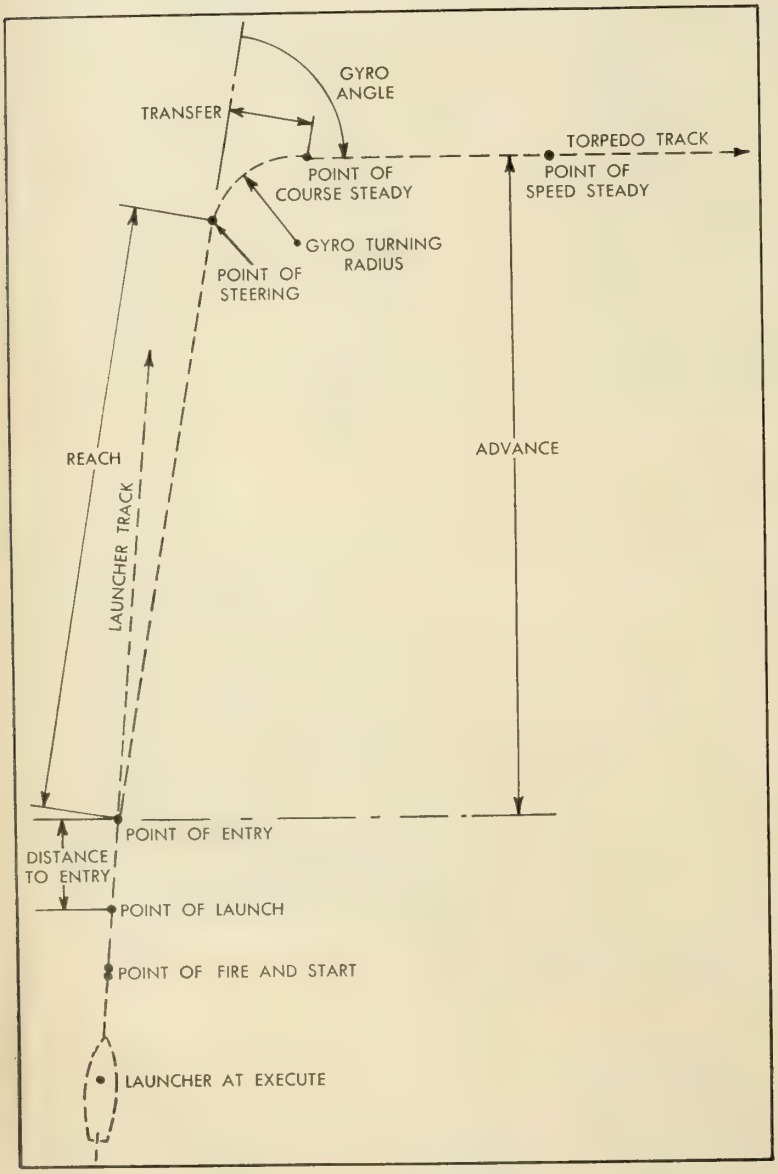




Rotation Terminology—Heel. (Some typical terms required to define rotation. Heel is designated as port or starboard.)



Rotation Terminology—Pitch.



Horizontal trajectory showing advance, distance to entry, gyro angle, gyro turning radius, reach and transfer.

characteristics of torpedoes have been generated more from the individual characteristics of particular torpedoes than from consideration of the fundamental cybernetics involved. It has not been possible to organize them into a system upon which a basic control language can be constructed. Consequently the terms defined largely represent only those in current usage.

Prior art has made the expression "acoustics" practically synonymous with intelligence, since development work has developed most rapidly in the field of acoustics. The terms listed in the glossary to define intelligence characteristics are, therefore, principally acoustic terms. This listing is not meant to preclude the use of analagous terms for other fields of development but simply reflects the fact that terms for other fields are not available for use at this time.

DEFINITIONS OF TERMS

Time Terms

READY. The instant that marks the completion of the preparation procedures for the exercise.

EXECUTE. The instant that marks the beginning of the torpedo exercise, normally considered zero time.

FIRE. The instant the verbal order to fire the torpedo is given.

START. The instant at which preset control from the launching vessel ceases.

LAUNCH. The instant the torpedo clears the launcher muzzle. For air or surface rack launchings, it is the instant the torpedo parts from the rack. In underwater launchings, launch marks the end of the launch phase.

ENTRY. The instant at which an air-launched or surface-launched torpedo strikes the water. For air-launched and surface-launched torpedoes, entry marks the end of the launch phase.

INSTANT OF STEERING. The instant at which the torpedo's direction controls become fully effective.

COURSE STEADY. The instant the torpedo is established on its preset gyro course.

DEPTH STEADY. The instant at which the torpedo is established at its preset depth.

SPEED STEADY. The instant at which the torpedo attains its constant running speed.

INSTANT OF ENABLING. The instant at which the torpedo becomes capable of making any control response to a detection.

INSTANT OF ARMING. The instant at which the firing device becomes fully capable of exploding the charge.

LOOK. The instant within a period of opportunity at which there is the maximum probability of target detection.

FLOOR REVERSAL. The instant at which the torpedo changes motion in depth search from down to up.

INSTANT OF DETECTION. The instant at which the stimulus of the target field becomes evident above the ambient field in the sensory system of the torpedo.

CEILING REVERSAL. The instant at which the torpedo changes motion in depth search from up to down.

INSTANT OF CONTACT. The instant at which the torpedo control mechanism first makes, in response to a detection, an action which would result in a change of direction of the torpedo.

INSTANT OF ACQUISITION. The instant at which the torpedo has completed accumulation of sufficient information to establish a trajectory which is compatible with its homing control law. Usually, three discreet points of the trajectory curve must have been established.

INSTANT OF ABORTION. The instant at which the torpedo, having lost its guidance information due to malfunction, initiates a new search phase.

INSTANT OF LOSS. The instant at which the torpedo, having lost its guidance information due to inherent limitations, initiates action for a new search phase.

INSTANT OF BLANKING. The instant when the torpedo reverts to memory control because external stimuli have saturated the sensing mechanism.

INSTANT OF HIT. The instant the torpedo physically strikes the target.

INSTANT OF MISS. The instant when the torpedo, in the terminal phase, passes the point of closest approach to the target.

RUN END. The instant the torpedo propulsion motor is shut down, generally signifies the end of the exercise.

Time Intervals

PREPARATION PHASE. The period between the time the torpedo test is first designed and start. The term has little significance as a descriptive expression of the exercise.

REACH TIME. The interval between start and instant of steering.

ADVANCE TIME. The interval between start and course steady.

TRANSIT TIME. The interval between start and depth steady.

PLUNGE TIME. The interval between start and speed steady.

TIME TO ENABLE. The interval between start and instant of enabling.

TIME TO ARM. The interval between start and instant of arming.

TIME TO 1ST (2ND, 3RD, ETC.) LOOK. The interval between start and the numbered look.

PERIOD OF OPPORTUNITY. The interval during which the target is continuously in the field of perception of the torpedo.

TIME TO 1ST (2ND, 3RD, ETC.) DETECTION. The interval between start and the numbered instant of detection.

TIME TO FLOOR REVERSAL. The interval between start and floor reversal.

TIME TO CEILING REVERSAL. The interval between start and ceiling reversal.

TIME TO 1ST (2ND, 3RD, ETC.) CONTACT The interval between start and the numbered instant of contact.

TIME TO 1ST (2ND, 3RD, ETC.) ACQUISITION. The interval between start and the numbered instant of acquisition or between miss and the number instant of acquisition.

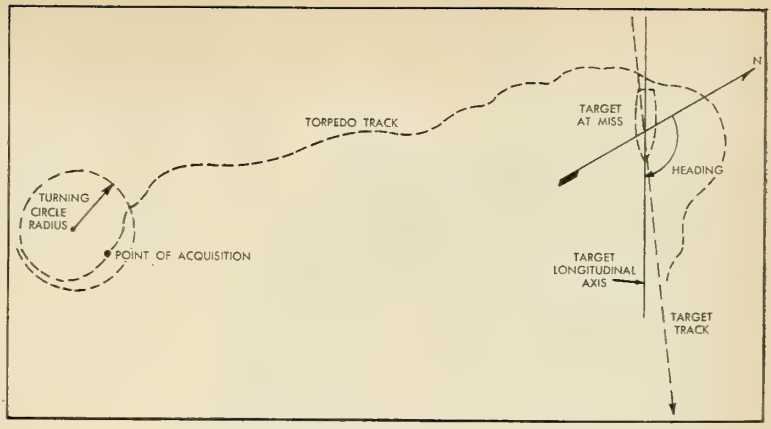
ACQUISITIVE PHASE. The interval between instant of contact and instant of acquisition while the torpedo maintains continuous sensory contact with the target.

PURSUIT PHASE. The period during which the torpedo is maneuvering along its trajectory in response to its guidance information. It occurs between the instant of acquisition and the instant of abortion, loss, or blanking. Pursuit phases occurring during a reattack are designated "reattack" and are identified by an ordinal number (1st reattack pursuit phase, 2nd reattack pursuit phase, etc.)

PRELAUNCH PHASE. The period between execute or ready, whichever occurs first, and start.

PRELAUNCH WARM-UP TIME. The interval between the instant the electronic circuits are partially energized and start.

TIME TO FIRE. The interval between execute and fire.



Horizontal trajectory—heading, turning circle radius.

TIME TO START. The interval between fire and start.

LAUNCHING PHASE. The period between start and launch or between start and entry, whichever occurs last.

TIME TO LAUNCH. The interval between fire and launch.

SWIM-OUT TIME. The interval between start and launch for underwater launchings in which expulsion is accomplished solely by means of the propulsion mechanism of the torpedo.

AIR-TRAVEL TIME. The interval between launch and entry. The term applies for air and surface-launched torpedoes.

TIME TO ENTRY. The interval between start and entry.

ATTACK PHASE. The period of initial search, pursuit, and terminal phases of a run, or initial search and pursuit phase alone if no terminal phase exists.

SEARCH PHASE. The period during which the torpedo is maneuvering into position to receive information of relative target position. It occurs between launch and the instant of acquisition (underwater firings), entry and the instant of acquisition (air and surface firings), or miss and the instant of acquisition. Search phases occurring after a miss are designated "reattack" and are identified by an ordinal number (1st reattack search phase, 2nd reattack search phase, etc.).

TIME TO ABORTION. The interval between start and instant of abortion or between instant of miss and instant of abortion.

TIME TO LOSS. The interval between start and instant of loss or miss and loss.

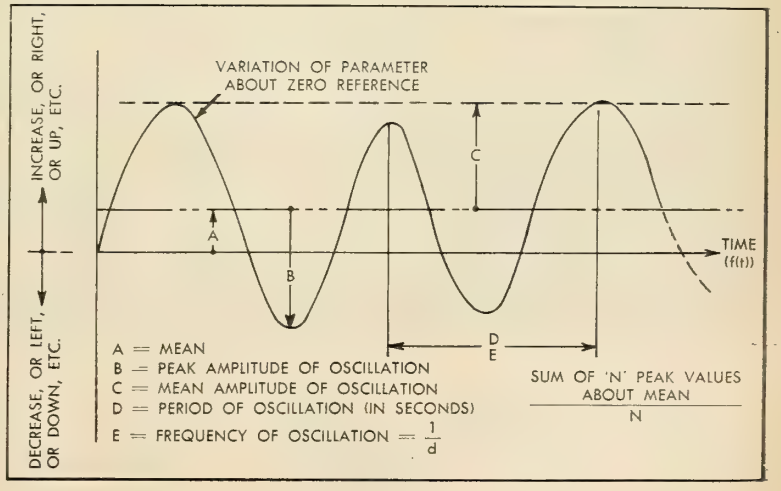
TIME TO BLANKING. The interval between start and blanking or miss and instant of blanking.

TERMINAL PHASE. The period following the last effective target-position indication in which the torpedo holds by memory the established collision course. It occurs between instant of blanking and instant of hit or miss. Terminal phases occurring during a reattack are designated "reattack" and are identified by an ordinal number (1st reattack terminal phase, 2nd reattack terminal phase, etc.).

TIME TO HIT. The interval between start and instant of hit.

TIME TO (1ST, 2ND, 3RD, ETC.) MISS. The interval between start and instant of miss.

REATTACK PHASE. The period during which the torpedo, recognizing that it has missed the target, initiates a new search phase to relocate it and ends at instant of hit or miss. A reattack phase will normally consist of a reattack search, pursuit, and terminal phase. Reattack phases are usually identified by an ordinal number, as 1st reattack phase, 2nd reattack phase, etc.



Time variation of motion.

ELECTRO-SNAP SWITCH & MFG. CO.

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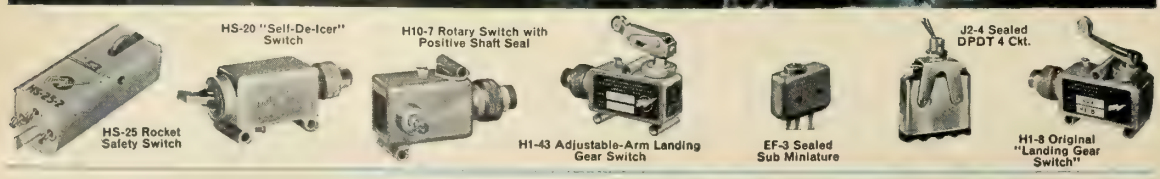
This same predictability is built into every Electro-Snap switch—aircraft or industrial—though the jobs they do may not always be so critical. In any case, reliability is delivered with the minimum size, weight and cost consistent with the job requirements.

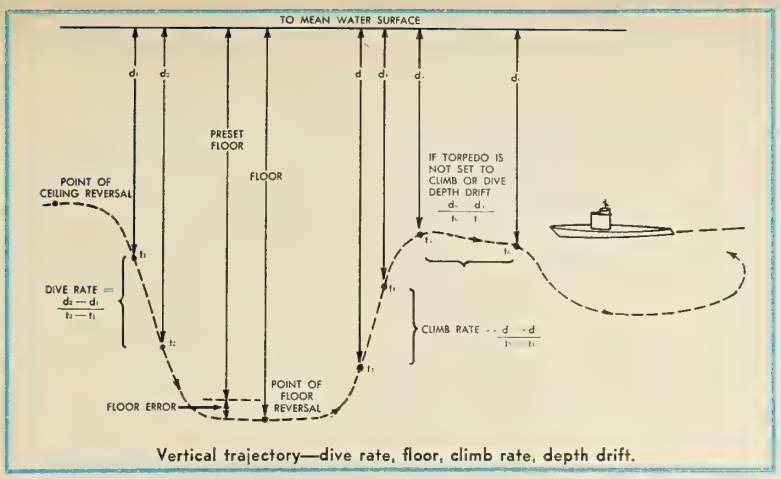
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ELECTRO SNAP





Vertical trajectory—dive rate, floor, climb rate, depth drift.

RUN TIME. The interval between start and run end.

Position and Motion Terms

HEEL. The angle between the vertical axis and a line perpendicular to the mean water surface through the torpedo's center of gravity. Heel is designated as port or starboard.

PITCH. The angle between the torpedo's longitudinal axis and a line parallel to the mean water surface in the longitudinal-vertical plane of the torpedo. Pitch is designated as up or down.

YAW. The angle between the torpedo's longitudinal axis and the velocity vector in the longitudinal-lateral plane of the torpedo; port or starboard.

ROLL. Heel oscillation.

ENTRY ANGLE. The angle between the longitudinal axis of the torpedo and the mean water surface at the point of entry.

Trajectory Terms

TRACK. The line generated from point to point on the horizontal plane by the motion of the center of gravity of the vessel.

ADVANCE. The distance between the mean torpedo track following the point of course steady and a line paralleled to this track passing through the point of entry.

DISTANCE TO (ARM, ENABLE, CONTACT, ENTRY). The distance along the torpedo track between point of start and point of arm, enable, contact, or entry.

GYRO ANGLE. The angle between the intended (preset) torpedo track and the direction of launch.

GYRO TURNING RADIUS. The radius, in yards, of a theoretical circle through the arc described by the torpedo track from the point of steering to course steady.

REACH. The distance along the torpedo track between point of launch (underwater firing) or entry (surface or air firing) and the point of steering.

TRANSFER. The distance between a vertical plane through the torpedo's longitudinal axis at launch and a plane parallel to this plane through course steady.

COURSE. The angle measured clockwise from true north to the positive direction of the mean track of the vessel.

COURSE ERROR. The angle between the positive direction of the intended (present) mean track of the torpedo and the positive direction of the actual track.

RATE OF TURN. The mean angular rate with which the torpedo changes course during a specified interval.

HEADING. The angle measured clockwise from true north to the positive direction of the longitudinal axis of the vessel at any instant.

TURNING CIRCLE RADIUS. The radius of a circle maneuver of a torpedo.

PATH IN DEPTH. The line generated from point to point on the depth plane by the motion of the center of gravity of the torpedo or target, as designated (torpedo path in depth, target path in depth, etc.).

CLIMB ANGLE. The angle between the mean torpedo path in depth during a climb and a horizontal plane through the torpedo's center of gravity.

CEILING. The vertical distance between the mean water surface and the center of gravity of the torpedo at the point of ceiling reversal.

CEILING ERROR. The deviation between the preset or intended characteristic and the value observed.

DIVE ANGLE. The angle between the mean torpedo path in depth during a dive and a horizontal plane through the torpedo's center of gravity.

DIVE RATE. The rate of change of depth during a programmed dive.

FLOOR. The vertical distance between the mean water surface and the center of gravity of the torpedo at the point of floor reversal.

FLOOR ERROR. The deviation between the preset or intended characteristic and the value observed.

CLIMB RATE. The rate of change of depth during a programmed climb.

DEPTH DRIFT. The rate of change of depth error when the torpedo is not preset to dive or climb.

DEPTH CUT-OFF. The vertical distance from the mean water surface to the center of gravity of the torpedo at which the energy to the propulsion motor is automatically cut off.

Location

LAUNCHER (AT ARM, ENABLE, FIRE, ETC.) The instantaneous location of the center of gravity of the firing vessel projected upon the course or depth plane at the instant of arm, enable, fire, etc. Any time instant may be employed with this term.

TARGET (AT ARM, ENABLE, FIRE, ETC.) The instantaneous location of the center of gravity of the target projected upon the course or depth plane at the instant of arm, enable, fire, etc. Any time instant may be employed with this term.

RANGE. The distance, in yards, between the centers of gravity of the target and the reporting vehicle.

RELATIVE BEARING. The angle measured clockwise from the positive direction of the longitudinal axis of the reporting vehicle (launcher, target, or torpedo) to a straight line connecting it with the other vehicle concerned.

TRUE BEARING. The angle, measured clockwise from true north to a straight line connecting the reporting vehicle with the other vehicle concerned.

LAUNCHER DEPTH. The vertical distance from the center of gravity of the torpedo to the mean water surface at fire. Applies to underwater launcher only.

LAUNCHER HEIGHT. The vertical distance from the mean water surface to the center of gravity of the torpedo at fire. Applies to above-water launchings only.

TARGET DEPTH. The vertical distance from the center of gravity of the target to the mean water surface. Applies to underwater target only.

TORPEDO DEPTH. The vertical distance from the center of gravity of the torpedo to the mean water surface.

LAUNCHER TORPEDO BEARING. The true bearing from the launcher to the torpedo.

LAUNCHER TORPEDO RANGE. The range from the launcher to the torpedo.

LAUNCHER TARGET RANGE. The range from the launcher to the target.

LAUNCHER TARGET BEARING. The true bearing from the launcher to the target.

TARGET TORPEDO BEARING. The true bearing from the target to the torpedo.

TARGET TORPEDO DISTANCE. The directed straight line distance between the center of gravity of the target and torpedo, equivalent to torpedo target range.

TARGET LAUNCHER DISTANCE. The directed straight line distance between the center of gravity of the target and launcher, equivalent to launcher target range.

TARGET LAUNCHER BEARING. The true bearing from the target to the launcher.

TORPEDO TARGET BEARING. The true bearing from the torpedo to the target.

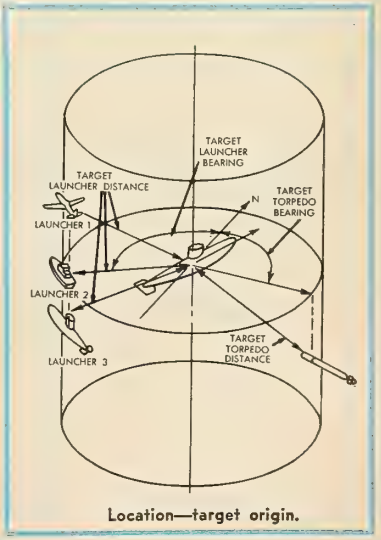
DEPTH DIFFERENTIAL. The vertical difference in depth between the target and the torpedo, measured in feet.

Time Variation of Motion

MEAN. The arithmetic average of the instantaneous values of the characteristic over a specified interval.

MEAN AMPLITUDE OF OSCILLATION. The arithmetic average of the maximum displacements of the characteristic with respect to the mean over the same interval specified for the mean.

PEAK AMPLITUDE OF OSCILLATION. The



Location—target origin.

maximum displacement of the characteristic indicated with respect to the mean over the same interval specified for the mean.

FREQUENCY OF OSCILLATION. The average number of cycles per second of a characteristic during the same interval specified for the mean.

PERIOD OF OSCILLATION. The mean time, in seconds, for one complete cycle of the characteristic indicated during the same interval specified for the mean.

Information and Control Terms

STEERING. Steering occurs when direction of the torpedo is controlled in both course and depth.

ENABLING. Enabling occurs when the torpedo becomes capable of making a control response to a detection.

ARMING. Arming occurs when the exploding device of the torpedo becomes capable of detonating the explosive charge.

OPPORTUNITY. An opportunity occurs when the target lies in the field of perception of the torpedo during a search phase. A PERIOD OF OPPORTUNITY is an interval during which the target is continuously in the field of perception of the torpedo. A look is the instant at which there is the maximum probability of target detection.

DETECTION. A detection occurs when the torpedo senses the target, receiving a signal that can be distinguished from the ambient field.

CONTACT. A contact occurs when the torpedo makes a control response as a result of a target detection.

ACQUISITION. An acquisition occurs when a contact endures long enough to establish a trajectory.

LOSS. A loss occurs when a torpedo enters a new search phase after having lost its guidance information during a pursuit phase because of inherent limitations.

ABORTION. An abortion occurs when a torpedo enters a new search phase or discontinues pursuit after having lost its guidance information during a pursuit phase because of torpedo malfunction.

BLANKING (GUIDANCE INFORMATION BLANKING). Blanking is an automatic electronic switch-off designed to occur when the intelligence system of the torpedo becomes so saturated that it can no longer make an effective control interpretation of the information received.

BLANKING RANGE. The distance from the torpedo to the target at which the target field is strong enough to operate the guidance information blanking circuit.

HOLD-IN. The action of a memory device that causes a torpedo to remember and continue upon the same trajectory during gaps in its guidance information.

COURSE HOLD-IN applies to memory guidance in course only.

DEPTH HOLD-IN applies to memory guidance in depth only.

ACOUSTIC RANGE. The range as determined by analysis of the transmitted and reflected signal.

COURSE DYNAMIC RESPONSE TIME. The time delay, in seconds, between receipt of a turn command and the first indication of its dynamic effect.

DEPTH DYNAMIC RESPONSE TIME. The time delay, in seconds, between receipt of an elevation command and the first indication of its dynamic effect.

ECHO AMPLITUDE. The average of the peak amplitudes of the pulses of energy which are reflected from the target and received at the torpedo.

ECHO FREQUENCY. The number of reflected signals received in one second.

ECHO PERIOD. The time between corresponding parts of two successive reflected signals.

ECHO TIME. The duration of a single reflected signal in milliseconds.

FIELD OF PERCEPTION. The nappe within which the directional sensory sensitivity of the torpedo is at least equal to one-half of the maximum.

GATING SENSITIVITY. The maximum amount of signal which may be received by the torpedo's control system which will not cause a gate circuit to function.

PING AMPLITUDE. The average of the peak amplitudes of the pulses of energy which are transmitted from the torpedo.

PING FREQUENCY. The number of pulses of energy transmitted per second.

PING PERIOD. The time between corresponding parts of two successive transmitted pulses.

PING TIME. The duration of a single transmitted pulse in milliseconds.

TRIP DIFFERENTIAL. The number of decibels by which the sum of echo and/or target noise from a target must exceed the sum of ambient and torpedo noise in order to cause a command response.

TRIP LEVEL ANGLE DOWN. The minimum number of degrees below the longitudinal axis of the torpedo from which a signal must come in order to obtain a down-trip of the depth signal relay.

TRIP LEVEL ANGLE UP. The minimum number of degrees above the longitudinal axis of the torpedo from which a signal must come in order to obtain an up-trip of the depth signal relay.

TRIP SENSITIVITY. The maximum amount of sound which may be received by the torpedo's control system which will not cause pick-up or energizing action of the course and/or depth command relays.

HOMING CONTROL LAW. The mathematical expression which most clearly describes the torpedo's track in the pursuit phase.

Environment Terms

AMBIENT FIELD. The absolute potential of the total field of influence, excepting the target and torpedo fields, within the perception capability of the torpedo.

AMBIENT NOISE LEVEL. The acoustic potential of all noise except that generated by the target and torpedo expressed as the equivalent pure tone pressure level in a band width of one cycle per second.

TARGET NOISE LEVEL. The acoustic potential of the target noise expressed as the equivalent pure tone pressure level in a band width of one cycle per second.

TORPEDO NOISE LEVEL. The acoustic potential of the torpedo noise expressed as the equivalent pure tone pressure level in a band width of one cycle per second.

SURFACE TEMPERATURE. The temperature of the sea, at or near the surface, in the area of the torpedo run.

MAXIMUM TEMPERATURE GRADIENT. The maximum rate of change of temperature with vertical distance. A 25-foot band within 100 feet of the depth limits of the run is normally used for measuring the maximum temperature gradient.

DEPTH OF BREAK. The vertical distance below the mean water surface at which an abrupt change in temperature occurs.

SEA STATE. The condition of the surface of the sea by BEAUFORT number.

Tactical Performance Terms

SEARCH PATTERN. The predetermined course the torpedo takes during the search phase.

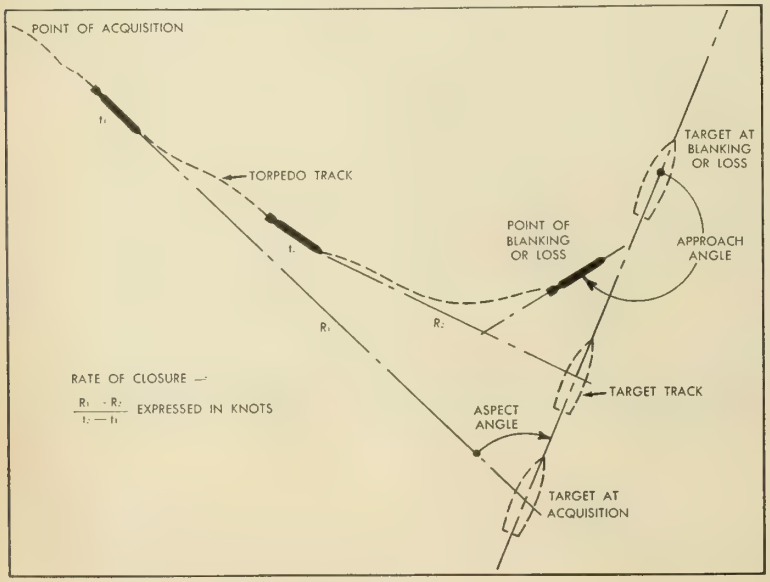
ASPECT ANGLE. The angle measured from the positive direction of the longitudinal axis of the target to a line joining centers of gravity of the target and torpedo.

APPROACH ANGLE. The average angle measured clockwise from the positive direction of the longitudinal axis of the target to the longitudinal axis of the torpedo during the terminal phase, or at the point of hit or point of miss if no terminal phase exists.

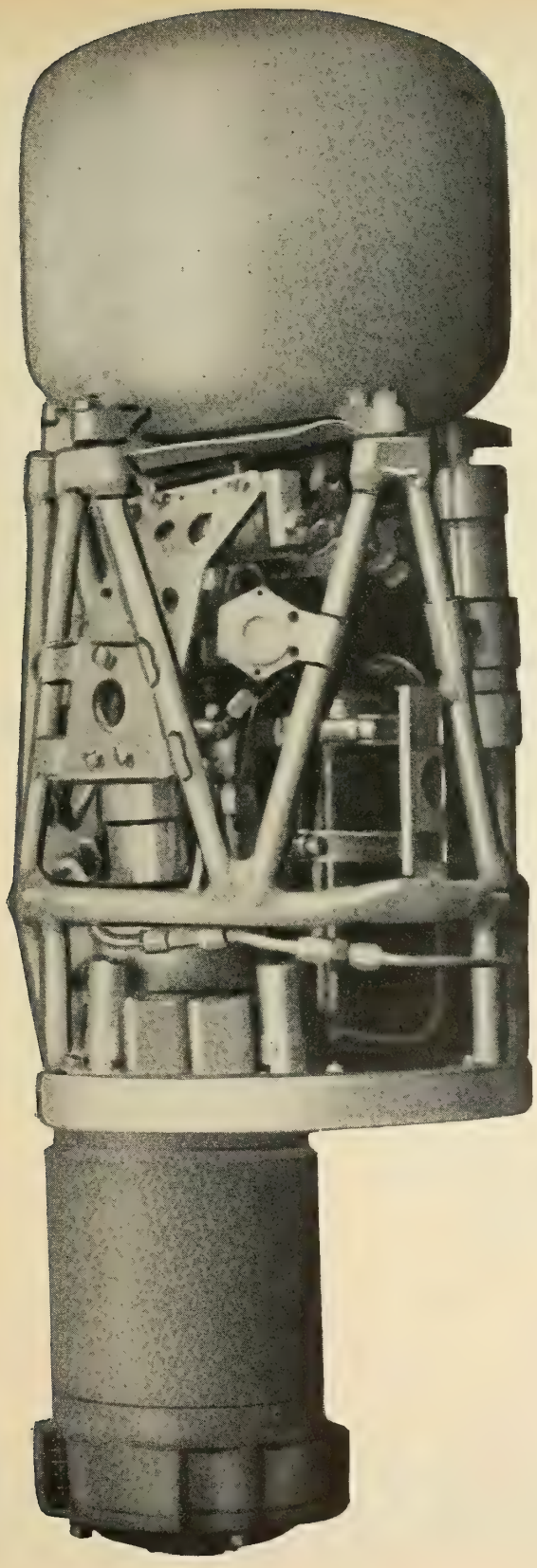
RATE OF CLOSURE. The mean rate, in knots, with which the range between the target and the torpedo decreases from point of acquisition to point of blanking, or from point of acquisition to point of hit or point of miss if no point of blanking exists.

MISS. Occurs when the torpedo, in the terminal phase, is no longer directed toward the target.

HIT. Occurs when the torpedo comes in physical contact with the target. ★



Tactical performance terms—approach angle, aspect angle and rate of closure.



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Fueling is one of the most important operations in the successful launching of a rocket. Since propellants are poisonous, breathing protection equipment must be worn. The Scott Air-Pak Model 8100-A2 has been designed to meet the exacting requirements of this hazardous operation. It delivers pure, fresh air, instantaneously "on demand" as required by the wearer regardless of the degree of exertion.

Special attention has been given to the metallurgy of the component parts to insure unfailing service in atmospheres of dangerous propellants such as fuming red nitric acid and unsymmetrical dimethyl-hydrazine.

The Scott Air-Pak has been established as standard equipment by Army Chemical Corps and Army Ordnance for launching crew protection.

Write for complete information.

The Scott 8100-A2 Air Pak incorporates the latest advances in chemical resisting materials. Two small compressed air cylinders are used instead of one large cylinder. This reduces bulk and makes the unit easier to wear with protective clothing.

The Scottoramic Mask which is standard equipment completely protects the eyes and face. It provides unlimited vision in all directions and helps the wearer to spot danger zones for maximum safety.

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NEW MISSILE PRODUCTS

LOX TRANSPORTERS



A variety of highway transport units for liquid oxygen and nitrogen handling is being built by Hofman Laboratories in sizes from 500 to 2,500 gal. capacity. All units are built to ASME and ICC specifications and feature use of company's powder-in-vacuum insulated equipment.

Among design features are a quick pressure build-up system, extended stem valves on liquid lines and use of Hofman quick disconnect couplings.

Circle No. 205 on Reader Service Card.

ROTARY TRANSDUCERS

A new line of rotary transducers for sensing angular displacement which utilizes unique construction features to obtain a high degree of instrument stability and accuracy has been announced by Crescent Engineering & Research Co. of El Monte, Calif. Different models exhibit linearity of ± 0.5% or better through 60° of best linear range, and of ± 1% over entire 120° linear range. Special design provides comparative insensitivity to ambient temperature changes.

Miniature precision ball bearings support shaft, otherwise there are no mechanical contacts between rotor assembly and bridge housing to produce friction or electrical noise. Sensitivity is 1 mv/v/o rotation, reproducibility is better than 0.1% and resolution is limited only by external circuitry. Operates in ambient temperatures from —70° to 180°F.

Circle No. 210 on Subscriber Service Card.

"BLINDRILLER"

The problem of locating "blind" holes in non-ferrous structural parts has been solved by the development of a tool named "Blindriller," according to an announcement of the Boeing Airplane Co., Seattle, Washington.

The new tool operates on a magnetic detection principle. A small magnet is inserted in the hidden hole in the structural member and the new device which contains a sensing tube housing a jewel-mounted pointer is placed on the outside skin. Since the pointer is tipped with a magnet having a polarity opposite that of the small magnet marking the hidden hole, the pointer seeks the hidden magnet as the tool is moved slowly around the surface. The hidden hole is accurately located when the pointer is "zeroed."

A slide arrangement supports both the pointer and a drill bushing. Once the hidden hole is located, this slide is shifted to the left as far as it will go and the drill bushing is brought directly over the center.

Although the locator is for use on non-ferrous structures, the close proximity of magnetic materials does not affect its operation. The tool is designed to give 90° angularity within 15 minutes of arc and a maximum .005-inch error in hole.

Circle No. 213 on Subscriber Service Card.

PUSHBUTTON SWITCH

A new "typewriter" pushbutton switch for manual keyboard control of electric equipment is being marketed by Micro Switch, Freeport, Ill., Division of Minneapolis-Honeywell Regulator.

It was developed for rapid-repeat, one-finger operation such as found in the keyboard of electric typewriters, adding machines and similar equipment. Extremely precise, low-force characteristics give the new switch both snap-action and "tap-action."

The new switch (designated the IPB81-T2) employs a single-pole double-throw precision subminiature basic switch for snap-action reliability. Switch and actuator can be operated at frequencies up to 300 times per minute.

The precision subminiature switch incorporated in the switch is listed by Underwriters Laboratories at 5 amperes 125 or 250 volts ac. The 30-volt dc rating is as follows: inductive, 3 amperes at sea level and 2.5 amperes at 50,000 feet; resistive, 4 amperes at sea level and 50,000 feet. Maximum inrush rating is 15 amperes, 30 volts dc.

Circle No. 250 on Subscriber Service Card.

SPEED REDUCERS

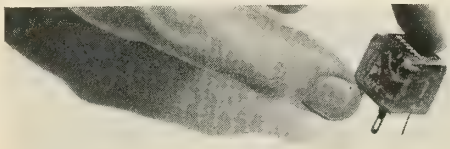
Western Gear Corp. announces the design and manufacture of a new in-line series of speed reducers to be marketed under the trade name "Straitline." Straitline reducers are available in double and triple reduction. Double reduction units

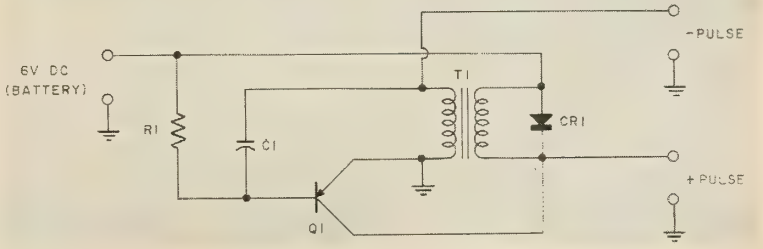
SUBMINIATURE OSCILLATOR

A blocking oscillator contained in an epoxy resin cube measuring ¾" has been produced by Allen B. DuMont Laboratories, Inc. The unit produces a pulse of three miscroseconds duration with a rise time of 0.08 microseconds. Repetition rate is 25 kc.

A six volt mercury cell will power the oscillator for about 1000 hours. Variations of the unit are available to give repetition rates from a fixed 1 kc or variable rates from 400 cps to 24 kc. Operating temperature is from —55°C to 66°C. Either external trigger or free running types may be obtained. Also, plug-in or solder in units can be furnished.

Circle No. 227 on Subscriber Service Card.



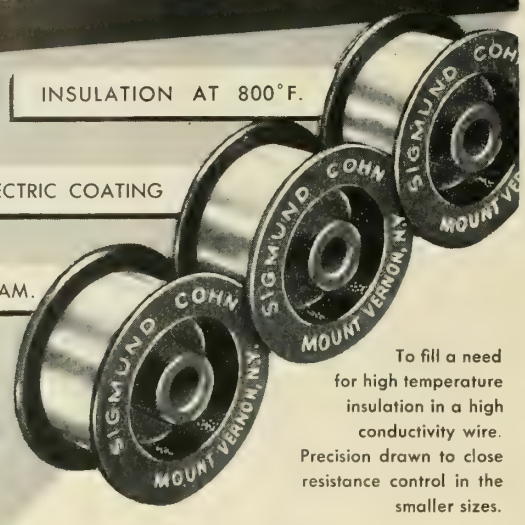


Anodized Aluminum Wire

INSULATION AT 800°F.

HIGH DIELECTRIC COATING

.0008" TO .030" DIAM.



To fill a need for high temperature insulation in a high conductivity wire. Precision drawn to close resistance control in the smaller sizes.

Specialists in the Unusual



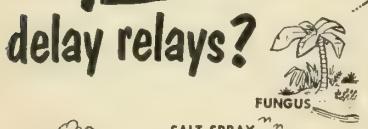
Write for List of Products

SIGMUND COHN CORP.
121 SOUTH COLUMBUS AVE., MOUNT VERNON, N. Y.
SINCE 1901

Circle No. 29 on Subscriber Service Card.

do YOU use time delay relays?





Do you require ADJUSTABILITY? . . . No Problem!
Do you require HERMETIC SEALING? . . . No Problem!
Do you require BOTH? NO PROBLEM for the

A. W. HAYDON Company

The A. W. Haydon Co. offers a complete line of ADJUSTABLE — HERMETICALLY SEALED TIME DELAY RELAYS for operation under adverse environmental conditions



Write for Bulletin AWH TD401

Bulletin AWH TD401 Describes
6400 Series — DC units
11400 Series — AC units
24300 Series — 400 cycle units
Nominal Range of Adjustment: 8-1
Timers supplied with:
AN connector
Hermetic Adjusting Knob
Glass Window and Calibrated Dial

Illustrated above are a few of the many environmental conditions which these compact timers are designed to withstand. More rigid requirements frequently can be met upon special consideration.

The A. W. HAYDON COMPANY
231 NORTH ELM STREET
WATERBURY 20, CONNECTICUT
Design and Manufacture of Electro-Mechanical Timing Devices

Circle No. 37 on Subscriber Service Card.

are offered in 15 standard ratios from 3.39:1 to 57.3:1 with ratings up to 100 HP. Triple reduction units are available in 9 ratios from 82.1:1 to 190.7:1 with ratings up to 50 HP. Straitline reducers feature complete interchangeability of individual parts throughout frame sizes as well as packaged sub-assemblies.

Circle No. 214 on Subscriber Service Card.

FLOATED RATE GYRO

Norden-Ketay Corp. has developed a floated rate gyro, Model 55,000 to meet current missile requirements with an accuracy better than ±½% full scale while the unit is subjected to a severe environment. The gyro can be supplied in a variety of maximum rate ranges from 6°/sec/ to 400°/ sec.



Damping is maintained without use of a heater by an arrangement which varies the gap between the gyro rotor float chamber and an adjacent member. Damping rate constant can be varied to suit customer needs. Size is 2" diameter by 2¾" long.

Circle No. 229 on Subscriber Service Card.

ROD END BEARINGS

Production of a new line of two-piece (ball and body only) self-aligning, plain, spherical, rod end bearings for the aircraft, missile and related industries is announced by Southwest Products Co., Monrovia, California. Patterned closely after Southwest Products' "Monoball" self-aligning rod end bearings, the new two-piece rod end bearings are said by the company to have longer cycle life compared to three-piece rod end bearings due to the construction and tougher materials used.

Circle No. 208 on Subscriber Service Card.

PRECISION GEARS

Precision gears especially suitable for servomechanism use are now offered by Beckman/Helipot Corp. as part of its standard electromechanical breadboard parts line. Spur, spring and clutch gears, and bevel and miter gears are among the types available.

In stock are 48- and 64-pitch spur gears, in tooth multiples of 8 and 10, with 14½° pressure angle, and minimum and

TECHNIQUES and DEVELOPMENTS in oscillographic recording

FROM SANBORN

RECORDING METHOD USED IN SANBORN DIRECT WRITERS, AND A REVIEW OF THEORETICAL AND ACTUAL ERROR FACTORS

Figure 1 shows the basic scheme by which Sanborn oscillographic recording galvanometers produce graphic records of electrical signal values. If the rapid deflection action of the heated ribbon tip stylus is visualized when current flows in the coil, it can be seen that a straight line at right angles to the chart length is recorded on the chart, at the point where the chart is drawn over a knife edge. The trace, therefore, is a true rectangular co-ordinate graph.

Since this is essentially a process of expressing coil (or stylus) deflection *angles* in terms of *distances* on a chart, the trigonometry of the situation (Fig. 2) must be examined to ascertain the accuracy of the method. Initially, and when θ is small, the tangent and the angle are almost equal numerically. The expression $D = R \tan \theta$ can, therefore, be rewritten $D = R\theta$ (approx.). To the extent this latter expression is true, deflection distances (rather than deflection angles) are an accurate measure of signal values. But to determine the extent of error resulting from using this approximation, the following data have been calculated*, using a chart width of 25 mm either side of zero ("D" in Fig. 2) and effective stylus length of 100 mm ("R" in Fig. 2) in the series expansion for the tangent function. Error as a function of deflection then becomes:

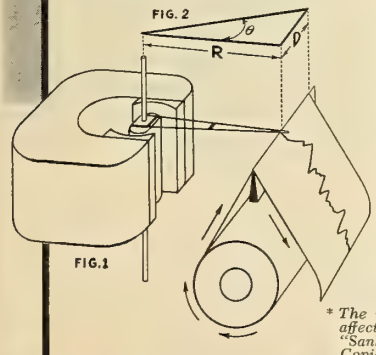


FIG. 1

D mms	Radians	Theoretical Error ϵ	Corrected Error δ	Corrected Error in mms
10	.10	.0033	0	0
15	.15	.0075	.004	.06
20	.20	.0133	.010	.20
25	.25	.0209	.018	.45

When the recording system is calibrated, that calibration is often made on the basis of a one centimeter deflection from the chart center, or by means of a two centimeter deflection starting one centimeter below chart center and finishing one centimeter above chart center. In either case the deflection at one centimeter from chart center is accepted as the standard, and, therefore, is without error. The foregoing table can therefore be corrected by subtracting .0033 from each of the error terms to show the error, δ, to be expected in actual use. The final column in the table shows this error in mms.

Since the active length of the stylus increases as θ increases, deflection D increases more rapidly than θ. All positive error terms in the series expansion bear this out, but the error terms would occur as predicted only if the galvanometer produced deflections exactly proportional to coil currents (that is, ideal spring properties in the torsion rods and uniformity of magnetic field). Pole tips in Sanborn galvanometers are proportioned so that in maximum deflections, galvanometer sensitivity *decreases* slightly, the compensation resulting in *actual* linearity better than that predicted in the table.

* *The mathematics involved here, as well as a discussion of fixed length stylii, design parameters affecting over-all galvanometer performance, etc., are contained in an article by Dr. Arthur Miller "Sanborn Recording Galvanometers," published in the May 1956 Sanborn RIGHT ANGLE. Copies are available on request.*

RECOGNIZE A "150" RECORD BY THESE *THREE* FEATURES...

1% Linearity

. . . resulting from use of current feedback Driver Amplifier in each channel, high torque galvanometers of new shorted coil frame design. Coil current of 10 ma develops 200,000 dyne cm torque, sensitivity is 10 ma/cm deflection.

Rectangular Coordinates

. . . save analysis time, simplify interpretation and correlation of multi-channel records. No waveform curvature, negative time lines, etc.

Permanent Inkless Traces

. . . made by hot nichrome ribbon tip of stylus on heat-sensitive Sanborn Permapaper. Clear, smudge-proof traces that clearly reveal minute signal changes.



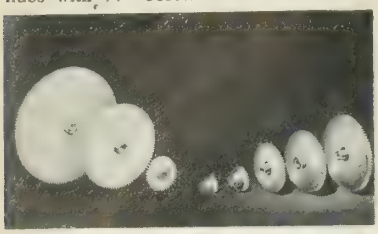
Call on Sanborn engineers for help with your oscillographic recording application in the 0-100 cycle range. Descriptive literature is also available on request, providing data on Sanborn 1-, 2-, 4-, 6- and 8-channel Systems, choice of 12 interchangeable plug-in Preamplifiers, Separate and Supplementary Instruments.

SANBORN COMPANY

Industrial Division

175 Wyman Street, Waltham 54, Mass.

maximum pitch diameters of 9/16" and 4" respectively. Stock gears have clamp hubs with ¼" bores.



Made-to-order spur gears are available in 32, 48, 64 and 96 pitches, with a choice of 14½° or 20° pressure angles and 1/8", 3/16" or ¼" bores, either clamp type or pin type. The latter are drilled and tapped for set screws and spot-drilled for taper-pin use. Delivery of made-to-order gears is within two to three weeks after receipt of order.

Gears with pitch diameter of 1" or less are stainless steel and have a 3/16" face width. Gears with pitch diameter over 1" are aluminum with stainless steel insert hubs, and have a 1/8" face width.

Circle No. 212 on Subscriber Service Card.

PLATFORM TRUCK

A new 20,000 lb. capacity low-lift platform truck, Model L-15, has been developed by the Elwell-Parker Electric Company, Cleveland.

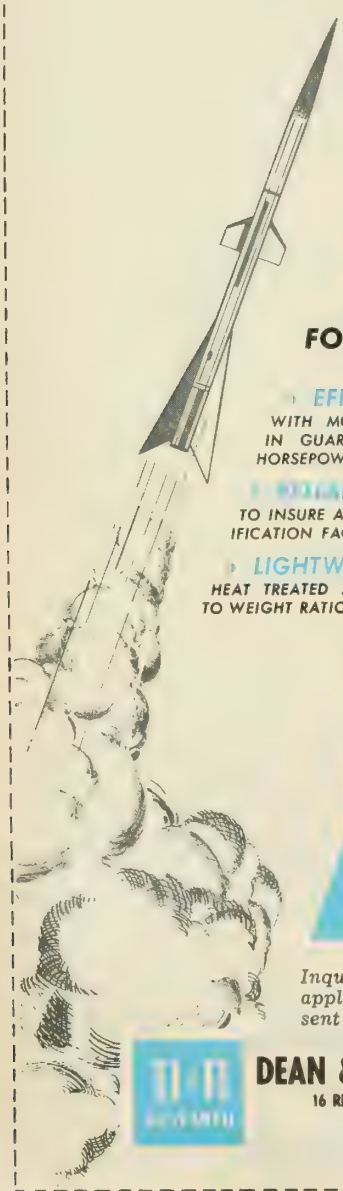
The truck is available with either electric or gasoline-electric power, has two-wheel drive and all-wheel steer. It is designed for handling odd-shaped and/or extra long loads, particularly where rugged duty is required.

The frame is built of heavy steel plate, formed and electrically welded. Center sill construction is used with all major units attached directly to the heavily reinforced alloy steel bars which form the sills.

The platform is raised by a double-acting hydraulic cylinder.

The truck features a rocking link type platform life with powered lowering accomplished with full inching control through a control valve. A safety link protects the lift mechanism in the event the platform is rammed against an obstruction. A heavy-duty, oversize electric motor drives a tandem hydraulic pump so that a separate oil supply is assured for both the hydraulic lift and the hydraulic steer cylinder.

Circle No. 224 on Subscriber Service Card.



D&B

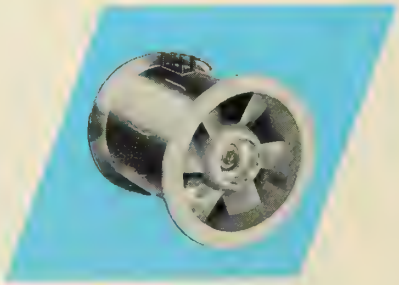
AXIAL-FLOW BLOWERS

FOR MISSILE APPLICATIONS

EFFICIENT — CONTINUOUS RESEARCH WITH MODERN FACILITIES PLUS EXPERIENCE RESULTS IN GUARANTEED PERFORMANCE FOR THE MINIMUM HORSEPOWER.

RELIABLE — EACH BLOWER IS VIBRATION TESTED TO INSURE A STRUCTURALLY SOUND UNIT. COMPLETE QUALIFICATION FACILITIES WITH THE DEAN AND BENSON PLANT.

LIGHTWEIGHT — WROUGHT ALUMINUM ALLOYS HEAT TREATED AND AGED PROVIDE A MAXIMUM STRENGTH TO WEIGHT RATIO.



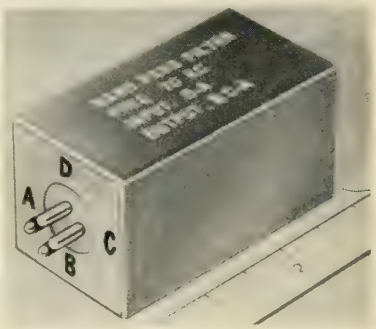
Inquiries regarding existing or future applications are welcome and should be sent to:

DEAN & BENSON RESEARCH, INC.
16 RICHMOND STREET CLIFTON, NEW JERSEY
Phone: GRegory 1-1600

Circle No. 31 on Subscriber Service Card.

TELEMETERING FILTERS

A new line of subminiature, lightweight telemetering filters for missile applications has been announced by the Pacific Coast Division of Aerovox Corporation. They are 2 cubic inches or less per unit. Telemetering filters for channels 1 through 6 are 1.562" high by .75" by 1.187"; weight is 71 grams (plus/minus 1 gram). Channels 7 through 18 are only 1.375" high by .75" by .75"; weight is 36 grams (plus/minus 1 gram).



Cast in an epoxy-filled resin, all units are hermetically-sealed and will meet applicable MIL Specifications for immersion, shock and environmental tests. All channels will pass 30 G's at 2000 cycles for 2 hours. Temperature range is —55°C. Channel points have standard Johns Hopkins band-pass telemetering call-outs.

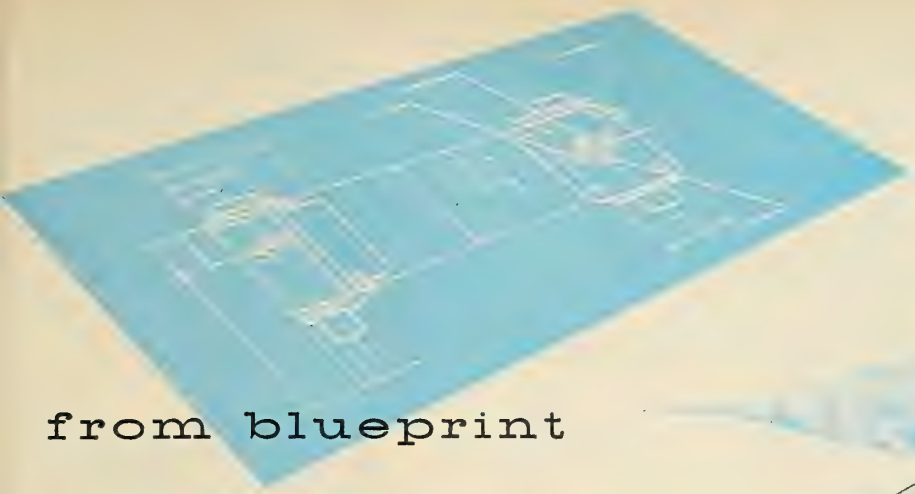
Units are made to plug into standard 4-pin Winchester sockets. Standard input impedance is 20K and output impedance is 100K, and can be varied to meet customers' specific requirements.

Circle No. 228 on Subscriber Service Card.

SHUT-OFF VALVES

A new series of high performance shut-off valves for airborne and ground use is now in production at Hydromatics, Inc. These units are designed for applications that require reliable, bubble-tight flow control of extremely low temperature (—320F) and high pressure (3000 psi) media. Typical gases and liquids handled include: oxygen, liquid oxygen, nitrogen, liquid nitrogen, air, liquid air, and helium.

Current is automatically shut off at the end of each valve cycle. In their open or closed position, the valve is positively locked by a Geneva-Lock



from blueprint

to blue skies



From design concept to volume production, Moog's contribution to high performance electro-hydraulics has been unique. Originators of force-balanced nozzle-flapper* and of dry-motor servo valves*, Moog alone has been able to translate these concepts into full volume manufacture. The 40,000 units in the field verify a production record unmatched in the industry. Consult Moog if this kind of design-to-production performance is desired.

*Patented
Other Patents Pending

ELECTRO-HYDRAULIC SERVO MECHANISMS

MOOG

MOOG VALVE CO., INC. PRONER AIRPORT, EAST AURORA, NEW YORK

Research Laboratory, Paramus, New Jersey



NEW

Trans-Sonics*

"TAPE-ON" SURFACE TEMPERATURE RESISTORS

for Temperature Telemetering

- NO THICKER THAN A PIECE OF TAPE
- OUTPUT UP TO 5 VOLTS WITHOUT AMPLIFICATION
- AVAILABLE IN VARIOUS RANGES FROM −300° to +400°F.
- RESISTANCE CHANGE OF 100 OHMS OVER SPECIFIED RANGE
- NO HOLES TO DRILL — QUICK AND EASY "TAPE-ON" INSTALLATION

Trans-Sonics Type 1371 "Tape-on" Surface Temperature Resistors are precision resistance thermometers with a platinum resistance winding as the sensing element. These resistors which are no thicker than a piece of tape may be applied to *any surface* whose temperatures are to be measured. In a commutation circuit, they modulate standard telemetering transmitters without amplification. The new Type 1371 "Tape-on" Surface Temperature Resistors may be added to an installation using other Trans-Sonics temperature transducers without any further circuit modification. Each resistor is furnished with 6" long fibreglas-covered constantan leads. Write for Bulletin 1371 to Trans-Sonics, Inc., Dept. 9.

*Reg. Trademark

SPECIFICATIONS

SIZE: ¼" x 5/16"

Accuracy: ±2% of full scale range

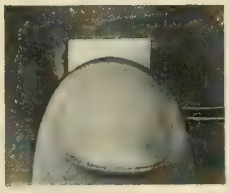
Precision: ±0.5% of full scale range

Maximum Continuous Current: 20 ma rms (averaged over 1 second)

Environmental Operation Conditions
Vibration: 1" double amplitude, 0 to 22 cps ± 25g, 22 to 2000 cps

Shock: 100g in any direction, per paragraph 4.15.1 of MIL-E-5272A (10 milliseconds shock)

INSTANT INSTALLATION



As easy to apply as a thumb print.

For Transducers, See Trans-Sonics

Trans-Sonics, Inc.

P. O. BOX 328 LEXINGTON 73, MASSACHUSETTS

Circle No. 206 on Subscriber Service Card.

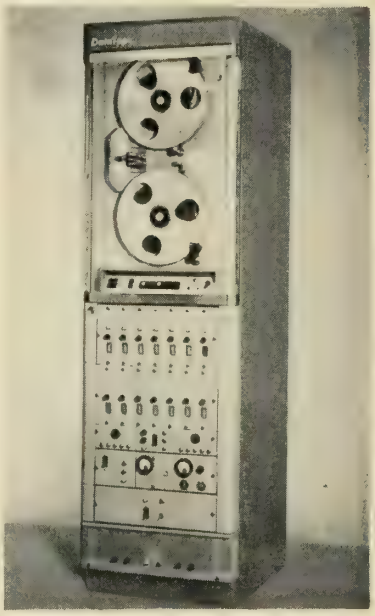
mechanism. Operating times from 0.5 sec to 5.0 sec are available.

Aluminum body; Aluminum and Hard Chromed Stainless Steel internal parts; Mylar, Kel-F and Teflon seals. Available per AND 10050, and 10056, or MS 33514. Elbows and other special configurations can also be specified. A complete range of line sizes is available, from ¼" to 1½". A typical ¾" model weighs 2.7 lbs. including motor actuator and valve unit.

Circle No. 217 on Subscriber Service Card.

MAGNETIC TAPE SYSTEM

Tape recorder and producer system for analog, PDM and FM telemetering has been introduced by Consolidated Electrodynamics Corp. The system provides for recording of seven separate tracks of signals on ½-inch tape.



Reels up to 14 inches are handled to give a capacity of 5000 feet of 1.5-mil tape. Tape widths of ¼, ½, ¾ and 1 inch can be handled. Frequency range is 0 to 100 kc at input levels from 0.25 volts rms to 25 volts rms. The new Type 5-752 unit weighs 880 pounds and operates from 115 volt supply.

Circle No. 223 on Subscriber Service Card.

GEAR MOTOR

Electro Products Division of Western Gear Corp. has developed a 30-volt dc permanent magnet governed planetary gearmotor measuring only 1¼ in. in diameter and weighing seven ounces.

The Model PG5B81RP65 motor requires one ampere current at 30 volts dc and has a 1.2 rmp output speed (±1%) with an output torque of 16 oz. in.

Circle No. 206 on Subscriber Service Card.

ROCKET SWITCHES

Line of precision switches introduced by Micro Switch, division of Minneapolis-Honeywell Regulator Co., are designed to resist effects of highly-corrosive gasses in rocket and missile applications.

Micro series 21AS is essentially an environment-proof, high-capacity switch unit attached to a rugged, cam-type actuator capable of withstanding heavy im-

Afterburner Cooling Assembly Gangs Straight Wall Tubing For High Strength, Light Weight

A minimum weight plus complex fabricating problems were critical factors in the development of this afterburner cooling blast tube assembly.

The space envelope was shallow and wide and over six feet long. The assembly was required to be tested at 28 psig with collapsing pressure of −2.5 psig and at a temperature of 250° F.

Flexonics answered the need by



End view of afterburner cooling assembly. Note rectangular shape of ends.

forming standard High Strength welded tubing into a gang. Ends of the tubes were formed to a rectangular shape to adapt them to the required end fittings. The tubes are held together with welded bands as the illustration of the unit shows. Tabs are provided for mounting in the airframe.

Tubing used in the assembly is 1.625″ O.D. by .011″ wall thickness. Type 321 High Strength stainless steel is used, with ultimate of 100,000 psi.

Facilities are the Key Factor

In the engineering, fabrication and proving of assemblies such as this, facilities are all important. As the pioneer and leading manufacturer of light weight corrosion resistant flexible assemblies and ducting, Flexonics Corporation has facilities second to none.

The engineering skill of Flexonics Corporation is proved by the scores of developments already made ranging from single flex connectors to entire aircraft ducting systems.

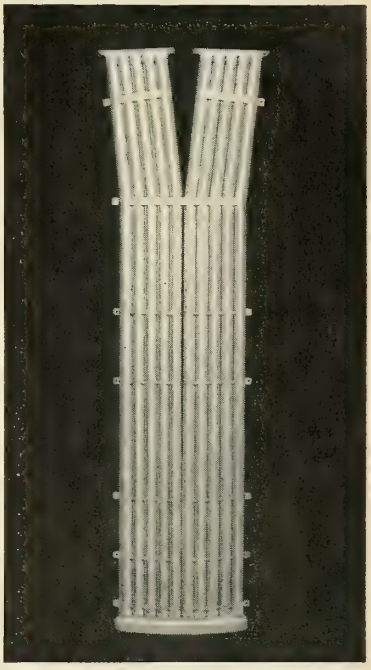
The manufacturing know-how of Flexonics Corporation is proved by the daily trouble free production of intricate assemblies and by such developments as the re-deposition process of forming ducting components.

The ability to prove assemblies before their installation in aircraft and engines is assured by the extensive Flexonics laboratories capable of the most advanced testing procedures.

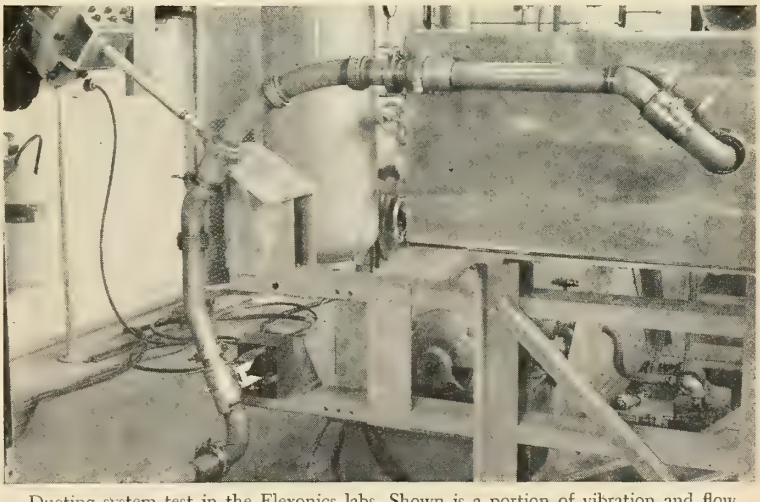
Engineering Assistance

Whenever you have a problem involving aircraft plumbing, take advantage of the know-how and facilities of Flexonics Corporation. For specific recommendations send an outline of your requirements.

For help right at your desk, write for information on how qualified persons can secure copies of the new Flexonics Engineering Manual.



Complete afterburner cooling assembly. Note use of straps to gang the tubing.



Ducting system test in the Flexonics labs. Shown is a portion of vibration and flow under pressure tests of assemblies in a bleed air system for a current fighter aircraft.

NOW, FROM FLEXONICS A COMPLETE LINE OF FLEXIBLE CONNECTORS AND DUCTING

With the acquisition of FLEX-O-TUBE Division, Flexonics Corporation is now able to offer a complete line of rubber, synthetic and Teflon hose assemblies and crimped-on and re-usable fittings. Write for full information.

AIRCRAFT DIVISION

Flexonics Corporation

1414 S. Third Ave., Maywood, Ill.

In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

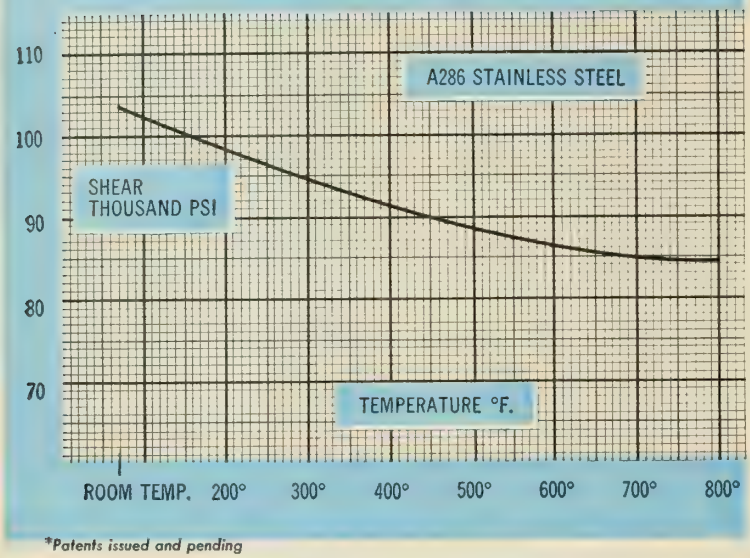
Also Manufacturers of: Industrial Hose • Expansion Joints • Bellows • Thermostats

A-34

Circle No. 33 on Subscriber Service Card

NOW, Cherry Rivet announces the

✓ HI-STRENGTH
✓ HI-TEMPERATURE
"600" Rivet *



*Patents issued and pending

Another new product by CHERRY RIVET research and development to meet the design requirements imposed by extremely Hi-Speed Aircraft and Missiles.

Wide Grip Range • Positive Hole Fill
High Clinch • Uniformly High Pin Retention
Positive Inspection

For additional data on the *new* Cherry "600" Hi-Strength, Hi-Temperature Rivet, write to Townsend Company, Cherry Rivet Division, P.O. Box 2157-Z, Santa Ana, California.

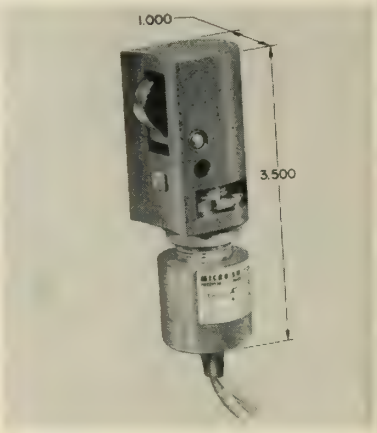
CHERRY RIVET DIVISION
SANTA ANA, CALIFORNIA
Townsend Company
ESTABLISHED 1816 • NEW BRIGHTON, PA.

In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

Circle No. 34 on Subscriber Service Card.

pact or hammer-type blows, according to its producer. Typical of its proposed use is an installation of the switch at the firing end of a tandem tube.

In this application, a front rocket holds the switch depressed, keeping the firing circuits to the aft rocket open until the forward rocket has left the tube. Once front rocket is fired, the switch releases and completes the firing circuit to the second rocket.

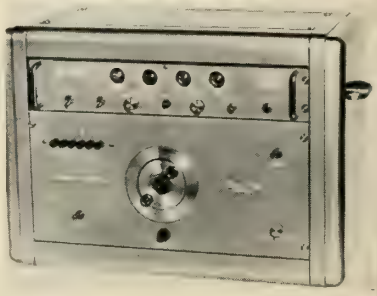


Design feature includes location of lead wires at bottom of switch for flexibility in mounting, two 0.120 in. diameter mounting holes, a 0.195 in. dia. mounting hole, and a 0.04 in. position stud to aid installation.

Circle No. 204 on Subscriber Service Card.

TACHOMETER CALIBRATOR

A new type of test instrument is announced by Servo-Tek Products Co., Model ST-901 Tachometer Calibrator. It is basically an electronic decade type counter combined with the maker's precision electronic adjustable-speed drive. The tachometer under test is driven at a speed (usually from 0 to 5000 rpm) that is infinitely adjustable by means of a 10-turn potentiometer. For rapid production testing, a push-button switch will select any one of five pre-determined test speeds.



The driving speed is continuously displayed with an accuracy of 1 rpm, plus line frequency error. Provisions are made for use of the counter for other purposes such as checking inverter frequency, telemetering switch counts, etc. Counting speeds up to 50,000 per second are possible. An electronic pick up is supplied as a standard accessory to permit checking the rotational or lineal speed of various motors, gear trains, etc.

Circle No. 215 on Subscriber Service Card.

TIME ACCELERATION SWITCH

An acceleration-time integrating switch for missile and rocket applications is available from the Magnavox Co. The unit is self-contained and is actuated by sustained acceleration in excess of the external biasing system. The unit is hermetically sealed and is said to conform to Air Force environmental specifications.

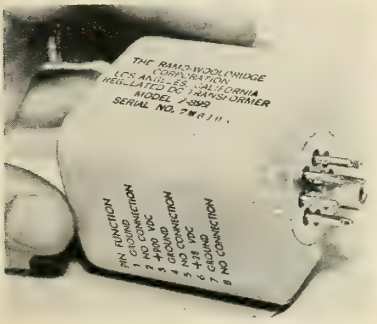
The switch can be adapted to a wide range of acceleration and time parameters for specific requirements. The available units give contact closure when the vehicle has reached a velocity of about 460 ft./sec. at between 4 and 15 g. Volume of the unit is 3 cubic inches and it weighs about 9 ounces.

Circle No. 222 on Subscriber Service Card.

CURRENT TRANSFORMER

A 900-volt regulated direct current transformer has been added to the selection of transistorized, DC power supplies manufactured by the Electronic Instrumentation Division, the Ramo-Wooldridge Corp.

Designed for use in high-performance aircraft, missile systems and other applications in extreme environmental conditions, the unit is potted in epoxy resin and sealed. It operates over an ambient temperature range of —55 to 70°C, and is unaffected by extremes of shock and vibration.



The new power package operates on 24 to 32-volt DC input and delivers 900-volt DC at 30 microamperes, regulated within 3%. Output ripple is regulated within 3 volts peak to peak. The entire unit—transistorized switching circuit, transformer, rectifier and regulator—is integrated in a 2" x 2¼" x 2¾" package.

Circle No. 216 on Subscriber Service Card.

CERAMIC INSULATORS

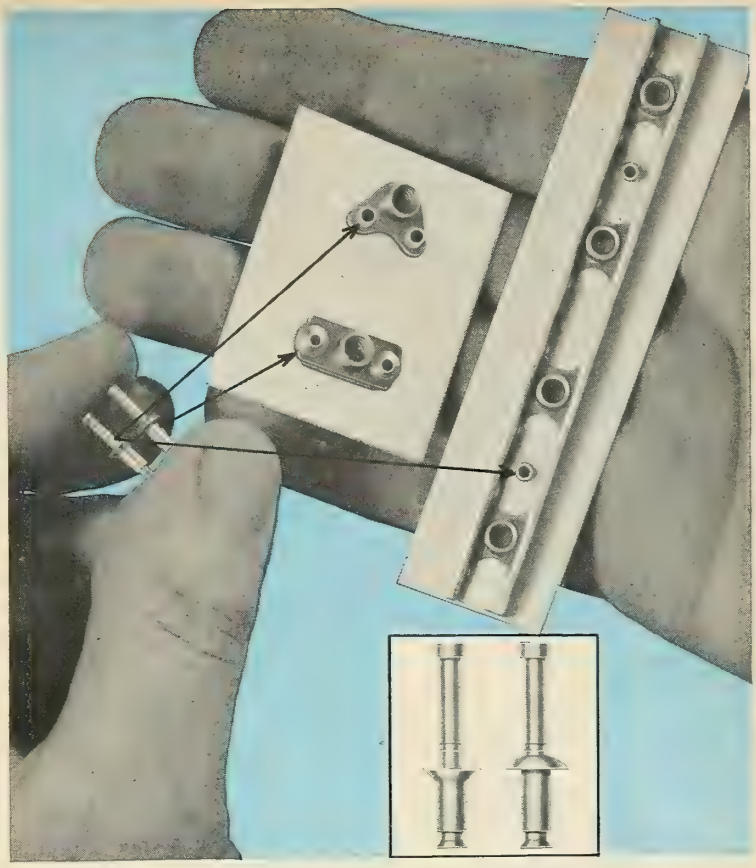
Special magnesium oxide tubing for insulating electric resistance wiring inside the metal sheathing of heating elements is being offered by Saxonburg Ceramics. New tubing is available in specified diameters and lengths, and with one or two holes for wire installation. Material used is said to be an excellent heat conductor and to be serviceable at temperatures up to 1,900°F.

Circle No. 200 on Subscriber Service Card.

ELECTROPLOTTER

A flexible high-speed plotter has been developed by Benson-Lehner Corp. which offers users of general purpose computers four degrees of freedom in presenting output data in graphic form. The "S" plotter accepts information from punched tape, cards or magnetic tape.

For flight trajectory tracing of mis-



For those "impossible" installations

Cherry Research Offers The 3/32" MONEL Hollow Pull-Thru Rivet

Available with either universal or 100° countersunk head, the Cherry 3/32" Monel Hollow Pull-Thru Rivet has a high shear strength particularly adapted to fastening nut plates, gang channel and honeycomb materials where extremely limited space makes use of solid rivets difficult. Damage to surrounding material in these difficult spots is eliminated with the pull-thru hollow rivet. Simplicity and speed of installation cut costs and save weight.

The new 3/32" Monel Hollow Pull-Thru Cherry Rivet can be installed with all existing Cherry Rivet guns, including the G-25 Hand Gun.

For technical information write to Townsend Company, Cherry Rivet Division, P. O. Box 2157-Z, Santa Ana, Calif.

CHERRY RIVET DIVISION

SANTA ANA, CALIFORNIA

Townsend Company

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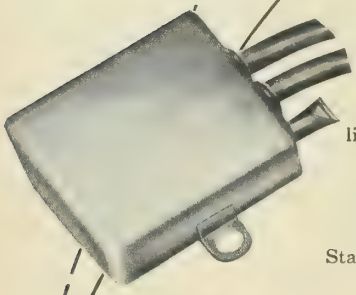
In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

Circle No. 35 on Subscriber Service Card.

Another New

CPI thermal switch

It's the versatile **FLAT-STAT**

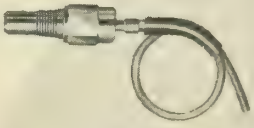


This new, highly sensitive, light weight, (weighs slightly more than ½ ounce) flat thermostatic switch is adaptable to signal unsafe surface or internal temperature of transformers, relays etc. as well as to control air conditioners in planes, and on motors and heaters. Because it is hermetically sealed, this new Flat-Stat can be immersed in non-conductive liquids to control temperatures in baths.

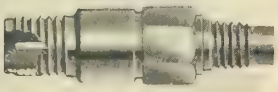
The Flat-Stat is available in 2 Amp. and 6 Amp. models. Calibration temperature range is −20°F to +650°F with momentary overshoot to 800°F. Standard tolerance is ±10°F but can be set to ±5°F if necessary. Repeatability is approximately ±1°F.

Wherever the need calls for a small, extremely accurate switch, investigate this new CPI Flat-Stat.

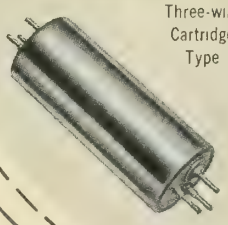
Ask about these CPI bi-metal switches, too



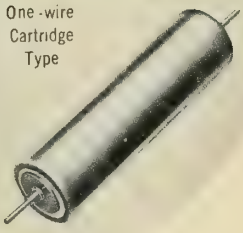
Plugstat Thermal Switch



Connector Type Plugstat



Three-wire Cartridge Type



One-wire Cartridge Type

439

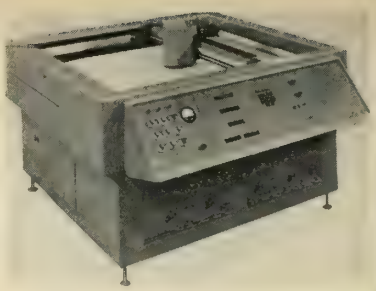
Ask our representative to tell you how CPI can help you solve your temperature control problem—and remember —when temperatures are high (or low) you can depend on CPI Write for complete engineering data.

Ask for catalog MR

Control products, inc.

HARRISON, N. J.

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siles, plotting of areodynamic pressures and stresses, etc. the plotter operates at rates of between 70 and 100 complete displays per minute. Digital and graphic information can be displayed.

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MEMORY DRUM

Over 12,000 bits of data and associated clock and reference information can be stored in a new miniaturized, magnetic memory drum developed by BJ Electronics, Borg-Warner Corp., Santa Ana, Calif. The device may be incorporated in data-handling systems and computer systems or utilized as a laboratory testing instrument.



The standard laboratory drum measures 3½ in. diameter and contains 12 information channels plus clock and fiducial channels. Each channel is 0.070 in. in width with a capacity of 1024 bits. Clock and fiducial channels are an integral part of the aluminum drum.

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BRIDGE BALANCE UNIT

A new Automatic-Calibrating Bridge Balance Unit, 24-202, recently developed by B & F Instruments, Inc., Philadelphia, Pa., for use in missile range instrumentation systems and in flight test programs of advanced military aircraft.

The new instrument is of value when recording dithering type information and provides calibration steps that are square wave for clearer interpretation.

Circle No. 207 on Subscriber Service Card.

DOUBLE WALL CONTAINER

Hoffman Laboratories, Inc. of Newark, N. J. has unveiled a container which will help companies operating in the Low Temperature Field to avoid repairs and evaporation losses. They feature a double wall separated by a high vacuum and highly polished internal surfaces for greater reduction of radiant heat losses.

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INDUSTRY SPOTLIGHT

By Joseph S. Murphy

Guided Missile Firms Again High on Defense Contract Lists

Guided missile airframe, guidance and powerplant producers ranked high on the list last month as Defense Department tabulated its top contract award winners for the 18-months from January 1, 1955 through June 30, 1956.

In all, some 19 of the first 20 firms are playing a prominent role in one or more missile or rocket programs. The only exception, Ford Motor Co., can hardly be considered an outsider in the missile business with the establishment last year of its new subsidiary, Aeronutronics Systems, Inc.

Heading the Defense list was North American Aviation, Inc. (*Navaho,* X-10 and liquid rocket engine producer) with $1,340.6 millions in contracts. General Dynamics (Convair) ranked second at $1,339.7 and is prime contractor for the *Terrier* and *Atlas* plus other missile projects.

Rounding out the billion-dollar group are United Aircraft (J57 engine for *Snark*) at $1,273.6 million; General Electric (*Hermes, Atlas* nose cone and guidance, J79 engine for *Regulus II*) at $1,051.2 million; and Boeing Airplane Co. *Bomarc* at $1,016.1 million.

Here's how missile firms shaped up in the million-dollar class of award winners: American Telephone & Telegraph Co. (Western Electric in *Nike* and Bell Laboratories in ICBM guidance)—$747.1 million.

Lockheed Aircraft Corp. (X-7, X-17 and *Polaris*)—$657.5 million.

Douglas Aircraft Co. (*Nike, Honest John, Thor* and *Ding Dong*)—$592.8 million.

McDonnell Aircraft Corp. (*Talos* and *Green Quail*)—$522.4 million.

Hughes Aircraft Co. (*Falcon*)—$477.1 million.

Curtiss-Wright Corp.—(Aerophysics HTV and *Dart,* ramjet for *Navaho*)—$464.2 million.

The Martin Co. (*Matador, Bullpup, Lacrosse* and *Titan*)—$406.0 million.

General Motors—(Allison J33 for *Regulus* and *Matador,* AC Spark Plug guidance for ICBM)—$326.3 million.

Bendix Aviation Corp. (*Talos* and *Loki*)—$295.4 million.

International Business Machines (computers for various projects)—$275.3 million.

Chance Vought Aircraft, Inc. (*Regulus* I and II)—$221.5 million.

Radio Corp. of America (*Talos* systems)—$221.3 million.

Sperry Rand Corp. (*Sparrow*)—$209.2 million.

Republic Aviation Corp.—(*Terrapin* rocket, ICBM nose cone subcontractor)—$200.8 million.

Missile representation throughout Defense's top 100 contractors includes some 13 other firms involved in major projects. On this list are Raytheon Mfg. Co. (*Sparrow* and *Hawk*); General Tire & Rubber Co. (Aerojet-General rockets); Goodyear Tire & Rubber Co. (Goodyear Aircraft's *Matador B* guidance and ground support); Northrop Aircraft, Inc. (*Snark*); Philco Corp. (*Sidewinder*); and Avco Mfg. Corp. (*Titan* ICBM nose cone).

Remaining seven included Westinghouse Electric Corp. (*Bomarc* guidance); Fairchild Engine and Airplane Corp. (*Goose* and *Petrel*); Bell Aircraft Corp. (*Rascal*); Firestone Tire & Rubber Co. (*Corporal*); Minneapolis-Honeywell Regulator Co. (ICBM guidance); Gilfillan Bros. (*Corporal*) (ground guidance system); American Bosch Arma Corp. (ICBM guidance); and Chrysler Corp. (*Redstone*).

General Electric Sets First Quarter Record In Sales and Earnings, President Reports

General Electric Co. set new first-quarter records in both sales and earnings during the first three months of 1957, President Ralph J. Cordiner has announced. Sales billed, he said, amounted to $1,048,850,000, an increase of 11 per cent over the previous first-quarter record of $946,458,000 set in 1956, and a 26 per cent increase over the first quarter of 1955.

Cordiner reported that General Electric plans to invest approximately $185 million in new plant and equipment during 1957. This, on top of expenditures of $205 million last year, indicates that the Co. will invest "substantially more" than the $500 million originally scheduled for expansion and modernization in its three-year program for 1956-58, he said.

Cordiner reported net earnings for the quarter of $64,006,000, up 16 per cent over comparable 1956 earnings of $54,962,000, and 22 per cent higher than first-quarter 1955 earnings. The earnings were equivalent to 73 cents per share of common stock and 6.1 cents per dollar of sales as compared with 63 cents per share and 5.8 cents per sales dollar for first quarter 1956, and 6.3 cents per sales dollar in the first quarter of 1955.

Also set new records in employee earnings and in payments to suppliers during the quarter, Cordiner said. Employee pay and benefits applicable to sales, during the quarter reached a record $399,141,000. Purchases of materials, supplies and services from the Company's approximately 42,000 suppliers amounted to approximately $485 million. Also made provision during the quarter for payment of $100,143,000 in direct federal, state and local taxes and renegotiation in addition to indirect taxes included in prices paid to suppliers.

Thiokol Builds *Nike* Sustainer

Nike-Hercules surface-to-air missile is to incorporate a Thiokol solid-propellant sustainer unit.

The new missile is scheduled to be in the hands of operational *Nike* batteries in the very near future. Its higher velocity will permit swifter interception of the most advanced types of aircraft, and its increased lethality will make *Nike-Hercules* one of the most effective weapons in American defense areas.

The sustainer unit is one of the many solid-propellant powerplants re-

cently developed by Thiokol Chemical Corporation.

The *LaCrosse, Falcon, Matador B,* and RV-A-10 all incorporate this type of powerplant. According to a recent announcement by the U.S. Army and the Western Electric Company, prime contractor for the *Nike System,* this new version of the *Nike* missile is now undergoing final tests.

Although longer, heavier, and more than double the diameter of *Nike-Ajax,* the *Hercules* model will have extreme maneuverability at altitudes far in excess of those capable of being reached by *Ajax.*

The *Nike-Hercules* is to be produced initially at the Douglas Aircraft Santa Monica plant and followed with additional production at the Douglas-operated Charlotte Ordnance Missile Plant at Charlotte, North Carolina. Nuclear capability will be incorporated into the *Nike-Hercules* surface-to-air guided missile system.

Reaction Motors Builds X-15 Engine

Air Force has confirmed that Reaction Motors, Inc., is developing an "advanced-design liquid propellant rocket engine" for the North American Aviation X-15 research airplane.

Missile Obligations Exceed $10 Billion In Eight Years, Aircraft Assn. Reports

Guided missile obligations for the eight years starting in June 1950 and ending June 1958 will total $10,173,930,000 or 8.2% of the $124,348,916,000 total Defense and procurement monies for the period, according to Aircraft Industries Assn.

However, the last half of this period accounts for better than 80% of the missile dollar obligations — $8,359,406,000 for fiscal years 1944 through 1958.

By individual service, AIA shows this summary of obligations:

Army—For eight-year period obligated $2,784,045,000 of which about $2.1 billion was obligated during fiscal 1955-58.

Navy — obligated $1,808,082,000 for eight years and, of this, $1,254,165,00 was for fiscal 1955-58.

Air Force—Eight-year obligations for missiles amounted to $5,581,803,000 of which $4,985,653,000 was obligated in the fiscal 1955-58 period.

Here's how missile obligations compared with total procurement and production monies for fiscal 1950 through 1958:

	Major Procurement & Production Funds ($000's)	Missile Obligations ($000's)
Fiscal 1951		
Army	$6,953,064	$34,600
Navy	6,092,476	119,090
Air Force ..	8,789,349	121,292
Total	21,844,889	274,982
Fiscal 1952		
Army	8,909,576	190,687
Navy	7,813,797	141,332
Air Force ..	11,979,814	68,417
Total	28,703,186	400,436
Fiscal 1953		
Army	3,489,999	212,915
Navy	5,009,174	154,124
Air Force ..	10,235,253	228,594
Total	18,734,426	504,633
Fiscal 1954		
Army	515,237	317,255
Navy	1,878,358	139,371
Air Force ..	1,928,592	177,847
Total	4,322,187	634,473
Fiscal 1955		
Army	2,185,568	349,554
Navy	1,404,537	116,589
Air Force ..	5,981,853	547,934
Total	9,648,793	1,014,077
Fiscal 1956		
Army	1,150,118	354,034
Navy	4,199,653	232,576
Air Force ..	7,141,587	859,719
Total	12,891,435	1,446,329
Fiscal 1957 (Estimated)		
Army	1,601,000	743,000
Navy	4,093,000	440,000
Air Force ..	8,425,000	1,888,000
Total	14,119,000	3,071,000
Fiscal 1958		
Army	1,359,000	673,000
Navy	4,245,000	465,000
Air Force ..	8,479,000	1,690,000
Total	$14,085,000	$2,828,000

SAM Details Revealed In Released Pix

English Electric has been permitted to release three photographs of its Napier-rocket powered SAM ordered for UK defense. The photographs have been released before, but not identified with English Electric. The missile has cruciform wings of 1.0 aspect ratio and cruciform tail guidance blades. Dipole antenna are featured both fore and aft. Take-off boosters are in four pairs on wrap-around explosive cord or bolt mount, each pair with a guidance fin. This type of booster is used on Napier's RJTV experimental ramjet.

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ROBERT L. EARLE, EXECUTIVE VICE PRESIDENT, *is second in command of the Marquardt engineering-production team. He is shown at Marquardt's new production plant now under construction at Ogden, Utah.*

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These freedoms — pioneering and growth — are as individual as each professional engineer, as collective as the entire Marquardt team. Through them, Marquardt now offers new and unlimited opportunity for professional engineers in two of the West's most stimulating areas. At Ogden, Utah, in the heart of the Wasatch Mountain vacation area, Marquardt is now constructing a multi-million dollar production plant to produce supersonic powerplants for the Boeing Bomarc interceptor missile. And in Southern California's San Fernando Valley, Marquardt professional engineers are involved in a major expansion program for design, development, and test of new ramjet engines and turbojet and ramjet controls.

If you are a professional engineer interested in the freedom to pioneer — the freedom to grow — for yourself and your company, we invite you to investigate the opportunities at Marquardt Aircraft, today. Please contact Jim Dale, Professional Personnel, 16551 Saticoy Street, Van Nuys, Calif.

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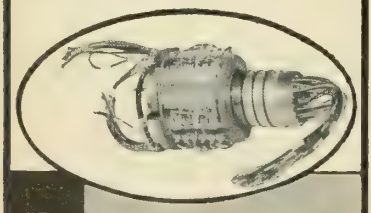
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Industry Highlights



By Fred S. Hunter

At the time of this writing—in April—the initial test firing of the Convair/Ramo-Wooldridge/Western Development Division *Atlas* prototype had not taken place at the Air Force missile test center in Florida, but perhaps by the time you read this the big event may have occurred. So let's call this *Atlas* month and talk about the big ICBM.

Karel J. (Charlie) Bossart, now technical director of Convair's Astronautics Division, named it the *Atlas*. It's a fitting name. Holds up the world. But there was an additional consideration at the time Bossart picked Atlas out of the dictionary. Convair's controlling stockholder then was Floyd Odlum's Atlas Corp.

Model number for the *Atlas* is SM-65, weapons system designation is WS-107A and Convair's house number for it is Model 7. Latter shows that Convair actually started on the ballistic missile project before its delta wing F-102 all-weather interceptor came along. The F-102 is the Model 8 on the Convair books.

Convair's Astronautics division currently is conducting its operations in the company's Plant 1 at San Diego—that's where the commercial Model 440 Metropolitans are assembled—but it expects to be fully established in its new home on Kearny Mesa in January next year. This $40-million domicile for Convair's prize bird includes a manufacturing facility, due for completion in November, an engineering building and two six-story office buildings.

Astronautics now has about 6,000 employes, and it will peak at about 7,000 in the new facility. It will have a couple of thousand more, however, at outside test locations. The division payroll will exceed $50 million a year.

Only recently did General Dynamics Corp. give Convair's Astronautics division full division status, like that of the company's Pomona Navy missile enterprise, but Convair has been working on an intercontinental ballistics missile program ever since April 22, 1946. That's when the Air Force gave it a study contract of very modest proportions—something less than $2 million, as we recall—for the MX-774. "Charlie" Bossert was the project engineer. Now, if you think the projected *Atlas* prototype test in Florida represents Convair's first test firing of a ballistic-type missile. You're wrong. There were three test vehicle firings of the MX-774 at White Sands in 1948. Reaction Motors made the four rocket motors powering the test vehicle.

The MX-774 was ordered terminated in the Louis Johnson economy program of 1947, but Convair was permitted to continue the project as long as the money originally budgeted held out. That's how it got in the subsequent test firings. But Convair was so thoroughly convinced of the nation's need for the "ultimate weapon" that even when the last dollar was spent it kept an engineering group on the project with its own funds. This was the situation when the Air Force came through in January, 1951, with a new contract for the MX-1593. This was the *Atlas*.

Atlas has grown considerably over the years. The MX-774, as we recollect, was 34 feet long. When Convair was ready to ship the *Atlas* prototype to Florida last December it had to truck it—a 10-day journey. Strangely enough, it attracted practically no curiosity en route. The people have become accustomed to seeing almost anything on the highway so those who passed the big canvas-covered shape on the road apparently didn't give it a second thought. One reason we were somewhat surprised when the Air Force shot down the Douglas C-132 for lack of funds the other day, was we had assumed all along that a primary function of the big turboprop would be to airlift such large-scale items as the *Atlas* and the Martin *Titan*. We understand the C-133 will hold the *Atlas*, but it's a tight fit—or so we hear.

Crucible Sales Top $70 Million

Crucible Steel Co. of America's sales of $70,598,795 in the first quarter of 1957 were the largest for any first quarter, but moderately below the level of the previous quarter, President Joel Hunter announced.

Net earnings for the first quarter amounted to $0.93 per share as compared with $1.01 per share in the 1956 quarter, based on the 3,638,562 common shares currently outstanding.

Directors elected for a three-year term of office were Joel Hunter, President; Walter H. Wiewel, Senior Vice President; Lawrence N. Murray, President, Mellon National Bank and Trust Co., and William H. Rea, President, Oliver Tyrone Corporation.

Honeywell Tests Guidance System

Minneapolis-Honeywell Regulator Co. has flight tested a new "pure" inertial navigating system for automatic guidance of manned or unmanned aircraft, it has been announced.

Several tests have been made from Honeywell's flight operations center at the Minneapolis-St. Paul Municipal Airport. The airplane which transported the highly-intricate aerial "brain" has ranged over several-hundred mile courses in Minnesota and Wisconsin.

Work on the system (designated ISIP, short for Inertial System, Indicating Position) has been going on for several years in the Aeronautical Division's research facility under a Navy development contract. The Air Force, too, has shown an interest in Honeywell's ISIP self-navigator.

Grumman Launches Bid For Subcontracting

Grumman Aircraft Engineering Corp., one of the few major aircraft firms not playing a major role in the current missile program, has launched a permanent subcontracting program that presumably will include missile work.

Company officials report that work complete and underway totals more than $7 million, with one order from General Electric worth in excess of $500,000 already delivered. Grumman also holds subcontracts from Sperry Gyroscope Co., Fairchild Aircraft Division, Chance Vought Aircraft and McDonnell Aircraft Corp.

All are active in one or more missile programs including Sperry (*Sparrow*), Fairchild (*Goose*), Chance Vought (*Regulus*) and McDonnell (*Tales* and *Green Quail*).

The Martin Co. Drops the "Glenn"

The Glenn L. Martin Co.'s stockholders have voted at their annual meeting to shorten the firm's name to "The Martin Company." This was done, the company said, "in keeping with industry's growing recognition of the greater impact of foreshortening company names."

Other formal business at the meeting included the re-election, as Directors, of George M. Bunker, Duncan M. Spencer and John L. Sullivan. Other Directors of the Company include Howard Bruce, William A. Burns, Jr., John E. Parker, Everett H. Pixley, Alexander B. Royce and Frank F. Russell.

At the meeting, it was announced that sales for the first quarter of 1957 were $98,748,234, an increase of 93 per cent over sales of $51,132,853 for the same period of 1956. Sales volume is approximately in line with the rate forecast for the full year.

The increase reflects both the higher current rate of activity as well as the fact that last year's first quarter

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WHAT'S THE WEATHER 30 MILES UP?
CDC WASP REPORTS BACK IN 60 SECONDS



THE WASP IS A SINGLE-STAGE SOLID PROPELLANT ROCKET
LENGTH: 103"; DIAMETER: 3"; WEIGHT: 22.5 LB.

That's a radar reflective chute just ejected from a CDC rocket launched only 60 seconds ago. Far below, a Navy research team is getting instantaneous answers to important weather questions—filling gaps in man's knowledge about wind profiles between *50,000* and *200,000* feet.

This missile system is currently performing useful research tasks for NOL, ONR, Redstone and the Signal Corps. It also is being employed in the IGY program. Redesigned from the LOKI missile developed by Cal Tech Jet Propulsion Lab for Army Ordnance, it is an outstanding example of CDC creativity. CDC offers full services in design, development, instrumentation, fabrication, field testing and data evaluation. How can CDC serve *you?*

Write for detailed information on CDC capabilities in rocket and electronic systems for scientific and military applications.

COOPER DEVELOPMENT CORP.

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SCIENTISTS AND CREATIVE ENGINEERS . . . INVESTIGATE THIS FIELD WITH A FUTURE. CHALLENGING WORKING ENVIRONMENT IN SOUTHERN CALIFORNIA.

DESIGNERS AND BUILDERS OF THE ASP — THE WORLD'S FASTEST SINGLE-STAGE SOLID PROPELLANT ROCKET

sales were somewhat less than normal.

Net income for the first quarter of 1957 was $2,009,535, equivalent to 69 cents per share compared to $1,586,725 and 56 cents per share last year. Net income, although ahead of last year's first quarter, is lower than expected for the rest of the year.

Bell Earns Slightly Less Sales Hit Peacetime High

Bell Aircraft Corp., manufacturer of the *Rascal* long-range air-to-surface missile, reports 1956 earnings of $5,761,103, down slightly from 1955. Sales of $216,033,290 plus other income of $1,040,937 marked a new peacetime high for the company.

Leston Faneuf, Bell president, attributed the decline in earnings to increased wage rates and material costs, unusually high starting load costs on products being built under fixed-price contracts, plus continually growing development and engineering expense.

In its annual report, Bell reported its engineers have designed and developed rocket engines for five guided missiles only one of which is now operational. It also reported completion of laboratory evaluation of more than 50 rocket propellants over a three-year period and some 15,000 rocket thrust chamber runs in more than 50 test cells it operates.

Bell now estimates it consumes about 350,000 pounds of oxidizer and 100,000 pounds of fuel each month in such testing.

Army Lets Contracts For New Lox Plants

Army Corps of Engineers has awarded a contract to Air Products, Inc. of Allentown, Pa. for construction of two liquid oxygen generator plants.

Each unit will be capable of producing a 50-ton daily supply of high-purity Lox for missile use, yet will be designed for dismantling and shipment via cargo aircraft. According to API officials, the largest air-transportable oxygen plant now in operations is rated to produce only 10 tons per day.

GE Sets Up Group For Missile Arming

Missile and Ordnance Dept. of General Electric Co. at Philadelphia has been expanded to include a special organization for R&D in nuclear arming and fuzing devices for missiles.

Group is designated the Nuclear Ordnance Projects Operation and will be responsible for all arming and fuzing development work including electro-

Missile Development Engineers

Electrical • Electronic Engineers with 2-6 years experience in

Magnetic and Transistor Amplifiers
Electrical Circuitry
Network Design
Inverters
Electro-Mechanical Analog Computers
AC and DC Servo Motors
Electronic Research
Missile Control Systems

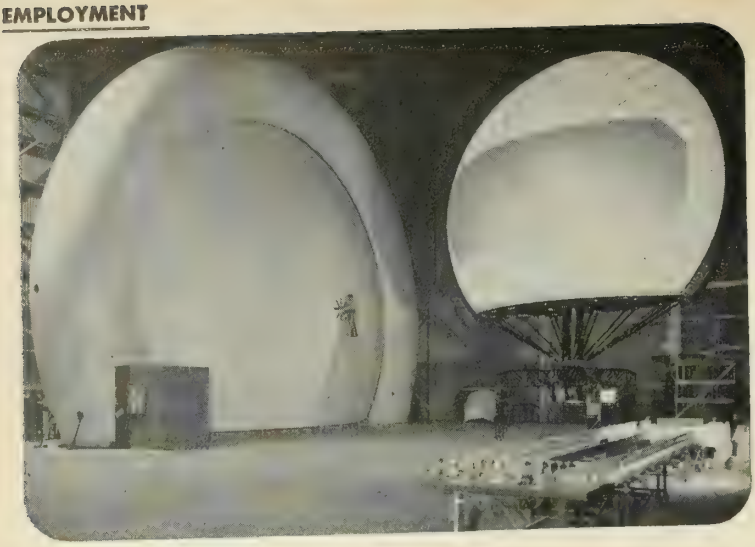
Mechanical Engineers with 2-6 years experience in

Inertial Guidance Systems
Gyro Development
Product Design and Packaging
Servomechanisms

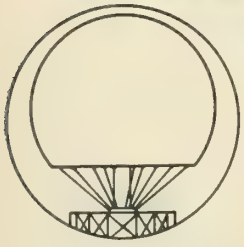
Ford Instrument Company's new Missile Development Division is expanding because of increased activity on guidance and control work for major ballistic missiles such as the Redstone and Jupiter.

Are you interested in the opportunities this could bring you — and the increased responsibilities? To those engineers who feel they can measure up to the high standards of our engineering staff and who wish to do research, development and design work in the expanding new field of missile engineering, write or phone Allen Schwab for an appointment or further information.

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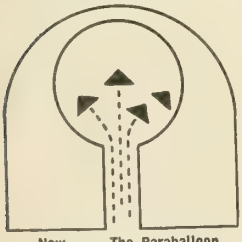
Exciting News About The Revolutionary "PARABALLOON"



The Original Paraballoon was mounted on a metal support. Only the antenna and balloon protector were air supported.

Westinghouse - Baltimore Engineers Have Adapted This Radical Antenna For Use In Scatter Communications

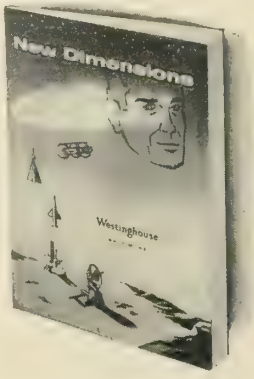
Just a few short months after the development of the Paraballoon by Westinghouse-Baltimore engineers, these same engineers have developed an entirely new application for it . . . which promises to revolutionize "over-the-horizon" scatter communications. The new Paraballoon application is just one more example of the pioneering leadership synonymous with the name Westinghouse-Baltimore.



Now . . . The Paraballoon is completely air supported — even lighter and more easily erected. Air supported structures as large as 65 ft. in diameter and over 100 ft. high are under study.

From Westinghouse-Baltimore comes an exciting new book every engineer's family should read.

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WESTINGHOUSE ELECTRIC CORPORATION
P. O. BOX 746, Baltimore 3, Maryland

Please indicate your degree, year of graduation, and field of interest.

For a confidential interview, please send a complete resume of your education and experience.

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Advanced Electronics Systems, Ordnance, X-Ray, Carrier Microwave, and Induction Heating Equipment for Military, Industrial, and Commercial Purposes.

SINCE 1886

mechanical devices used to arm and detonate missile warheads.

G. F. Metcalf, department general manager, said the group has contracts requiring production of recently developed system designs for current Army Ordnance missile warheads, as well as R&D into new and improved systems for future operational missiles.

Farnsworth Contracts Over $12 Million

I. G. Haggerty, President of Farnsworth Electronics Co., Fort Wayne, Ind., a division of IT&T, announced that the company had received additional orders amounting to more than $12-million from the Boeing Airplane Co. in Seattle, Wash.

The contract calls for the provision of additional ground support and operational test equipment for the Bomarc Missile, currently being produced by Boeing for the USAF. According to Mr. Haggerty, Farnsworth, long active in the production of automatic and specialized test equipment for missiles and for other complex electronic and electro-mechanical devices, did the original prototype development of the equipment just ordered.

Small Business Contracts Hit $1.6 Billion

Subcontract awards by 163 large firms to small business almost matched the dollar volume received directly from the Defense Department in prime contracts during the last half of 1956, Defense officials report.

Major companies participating in Pentagon's Small Business Subcontracting Program reported $1.430 billion awarded small business during the period compared to $1.616 billion awarded by Defense as prime contracts.

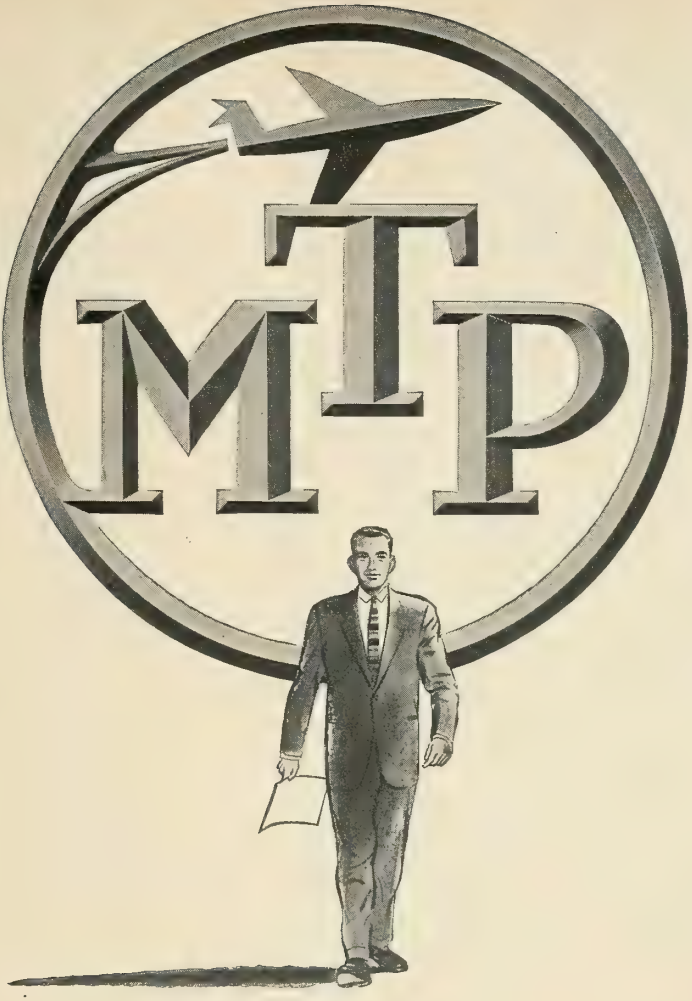
According to Pentagon estimates, the $1.430 billion represents 20.9% of the total military prime and subcontract receipts of the 163 firms reporting receipts and payments under Army, Navy and Air Force contracts.

Brush Sets Up Branch in L.A.

Brush Electronics Co., Cleveland, Ohio, manufacturers of industrial and research instruments, has established a factory branch office in Los Angeles.

This new facility will serve as western regional headquarters for service and repairs in the western states and will be the headquarters for the western regional sales manager.

The team of sales engineers is already on the job and additional per-



SYMBOL / OF AN ENGINEER'S FUTURE...

RCA offers the opportunity for you to apply your engineering talents to its Missile Test Project at Patrick Air Force Base, Florida—"Launching Site of the Satellite."

Here at the world's largest missile testing laboratory, extending from Florida far across the South Atlantic, you can enjoy professional status with the recognized leader in electronics. Unprecedented growth opportunities are offered in various phases of data acquisition, transmission and processing, including Radar—Communications—Optics—Computers—Timing—Telemetry.

At RCA's Missile Test Project you will enjoy professional advancement combined with famous Florida living. You and your family will appreciate the ideal climate on Florida's Central East Coast which allows year 'round outdoor activities.

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Employment Manager, Dept. N-33E
RCA Service Company, Inc.
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New long range projects assure not only challenging, high-level creative work, but security and job stability as well. Excellent starting salaries plus all the resort and cultural advantages of suburban Long Island living. Moving allowances arranged.

A partial listing follows. Information on many more positions may be obtained by contacting Robert Burchell at the address below.

MISSILE PROJECT ENGINEER
Coordinate project analysis, planning and controls including determination of project requirements and commitments in missile field.

ELECTRONIC SYSTEMS ENGINEER (Field Service)
Liaison with associate contractors and government agencies on inertial guidance system project. Must be thoroughly familiar with matters relating to digital and analog computers, power supplies, environmental conditions, housing and test facilities and test equipment.

FIELD EVALUATION ENGINEER
Perform overall planning functions for field evaluation of missile guidance systems. Direct activities in scheduling the field operations. Liaison with field test site agencies and formulating overall operating procedures at test site on missile project.

MECHANICAL DESIGN ENGINEER
Perform mechanical design of airborne instrumentation and transducers required for field evaluation of missile guidance systems. Responsible for packaging and mounting equipments.

FUNCTIONAL ENGINEERS—MISSILE SYSTEMS
Develop inertial guidance systems including gyro, accelerometers, integrators, servo systems and computers. Analyze functional problems arising during development and evaluation of said system.

OPERATIONAL EVALUATION ENGINEER
Perform engineering studies and analysis of techniques for evaluating performance of missile guidance systems and its components including gyros, accelerometers, digital computers.

PLATFORM ENGINEER
Conduct investigation of a theoretical nature relating to gyros or inertial platforms including design of closed loop control equipment pertaining to the above.

GYRO DEVELOPMENT ENGINEER
Develop precision gyro systems including mechanical problems such as lubrication, temperature controls, hydrostatics and vibration and electronic work on accelerometers, amplifiers, torquing circuits and electrical pickups.

OPERATIONAL ANALYSIS ENGINEER
Development work on evaluation of inertial guidance systems including in-plant and flight analysis of gyro systems. Development of measuring devices for precise determination of in-flight velocity, acceleration, altitude and position information.

RELIABILITY ENGINEER
Develop methods for evaluation of accuracy, reliability and operational suitability of missile guidance systems.

SYSTEMS EVALUATION (MISSILE GUIDANCE)
Perform functional engineering studies and design of inertial guidance systems, determine system and component requirements and performance, conduct system and component dynamic studies and simulation, perform error analysis.

PROJECT ENGINEER—
PRODUCTION TEST EQUIPMENT
Administer and technically direct the program of design, development and manufacture of test equipment for production use in the manufacture, inspection, test and reliability control of highly complex electronic, electro-mechanical and gyroscopic equipment required for missile application.

GROUND EQUIPMENT ENGINEER
High degree of technical and administrative responsibility on complex projects involving the design and development of production test and field test equipment for gyroscopic systems and digital computers.

PROJECT ENGINEER—AIRBORNE EQUIPMENT
Guide and assist engineers in technical problems in field of electrical and electronic design, servo systems, missile guidance systems. Responsible for major product improvement program and test programs. Provide technical liaison with quality control. Heavy servo background desired.

ENVIRONMENTAL ENGINEER
To plan, conduct and report upon development studies of finishes, materials and processes, which will be incorporated into the design of electromechanical and electronic components and systems.

OPERATIONAL ANALYSIS ENGINEER
To plan, conduct and report upon environmental tests of electromechanical and electronic systems. Must be capable of redesigning components or systems to correct any deficiencies encountered during the evaluation program in the computer, servo systems and missile field.

QUALITY CONTROL ENGINEER
Require experience in gyroscopic trouble shooting. Design knowledge of stable elements and some background regarding reliability and failure association for complex guidance systems to be used in missile field. Must have complete knowledge of statistical methods.

GROUND EQUIPMENT ENGINEER
Plans and performs engineering studies, basic electrical and mechanical design, development and evaluation of production test and field test equipment where specific objectives and general requirements are known. Must be familiar with electromechanical instrumentation.

Clip the job (or jobs) you're interested in and mail, with your confidential resume. No reference contact without your permission. You'll receive a prompt reply, and your copy of "Your Engineering Career with Arma," full of detailed information about this company.

Mr. Robert Burchell
Technical Personnel Dept. M-674
Division American Bosch Arma Corp.
Roosevelt Field, Garden City, L. I., N. Y.

ARMA

sonnel will be added as required, said C. B. Hoffman, sales vice president.

Martin Awards Contract For New Orlando Plant

The Martin Co. has let contracts totaling $6,031,950 with Thompson & Street Co. of Charlotte, S. C. for construction of a new plant at Orlando, Fla., location of its present *Lacrosse* missile production.

The new facility, situated on a 6,777-acre site purchased by Martin last September, is slated for use in R&D and production of newer weapons in the missile, electronics, nucleonics and small weapons fields.

Martin is handling *Lacrosse* manufacture in interim facilities near Orlando and presumably will shift this activity to the new plant when completed later this year.

Plan for the new structure calls for about 488,000 sq. ft. in four buildings. Main building measuring 640 by 500 ft. will provide 290,000 sq. ft. of manufacturing, assembly, shop and storage space.

Southwestern Gets Convair Contract

Southwestern Industries Inc., Los Angeles, has received a contract from Convair, a division of General Dynamics Corp., for design and manufacture of pressure switches, Southwestern President F. P. Jenks has announced. The switches will be used in classified missile applications by Convair-Astronautics in San Diego, Jenks added. Dollar value of the contract was not disclosed.

Texas Nuclear Installs Atom Smasher

Texas Nuclear has completed installation of its "atom smasher" at Austin, Tex.

The company initially is using its 2-million-volt positive-ion accelerator purchased from High Voltage Engineering Corporation, Burlington, Mass., in programs dealing with elastic and inelastic scattering of neutrons.

Missiles Support Functions to go to San Bernardino

Transfer of the Ballistic Missiles logistical support functions, now at Maywood Air Force Depot to Norton Air Force Base at San Bernardino, Calif. will take place in the near future, it has been announced.

The Ballistic Missile Management

An Announcement

OF FIRST IMPORTANCE TO EXPERIENCED ROCKET ENGINEERS AND SCIENTISTS

- *Reaction Motors initiating big new Research and Development Program*
- *Key spots offered to men who have already made a name for themselves in Rockets*

If you're one of the relatively few trained rocket men in America, your experience will pay off handsomely at Reaction Motors. The first rocket company in America, RMI is now entering its period of greatest expansion, a period that will see far-reaching developments in America's fastest-growing industry. Your participation in RMI's program during this crucial period is your best guarantee of leadership in the industry. In a job like one of those listed below you'll be strategically placed for both achievement and advancement.

1. Senior Design Engineer

Prefer ME or AE degree and a minimum of 6 years experience in aircraft engines or airframes. You should have extensive design experience, including plenty of board time, shop contact, structural design, stress analysis. You will be working directly with design engineers and layout draftsmen on design of light weight, complex structures.

2. Instrumentation Engineer

BS minimum in mechanical, aeronautical or electrical engineering; 3-5 years experience on aircraft engines. Must be familiar with the application of instrumentation to testing of rocket or other aircraft engines, the utilization of currently available instrumentation, or the modification and adaptation of such instrumentation for particular requirements and wide limits of flow temperatures, pressure, thrust, etc.

3. Stress Engineer

Degree in engineering or applied mechanics. Required experience in mechanical design with emphasis on stress analysis; 3 years for an engineer, to 6 years for the senior engineer. Must be able to handle and/or supervise involved analyses—including the effects of dynamic forces, high temperature gradients and high pressure differentials—under conditions where light weight is vital.

4. Product Engineer

BS in ME, AE or equivalent with a minimum of 5 years airframe powerplant experience. Your background should also include engineering and customer contact on technical products and services. You will assume responsibility for organizing a program to apply new and existing powerplants to all types of missiles. 2-3 days of your week will be spent answering inquiries and preparing proposals, 2-3 days traveling.

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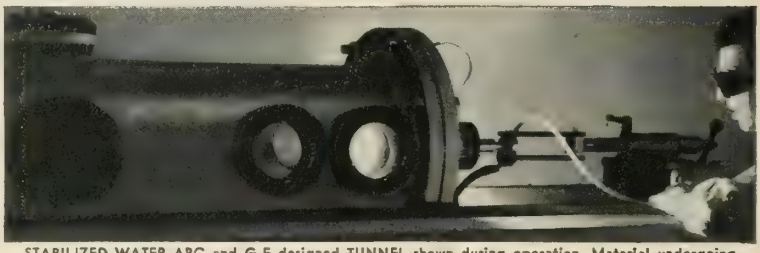
50 FORD ROAD • DENVILLE, N. J.

ENGINEERS-SCIENTISTS: TEMPERATURES TWICE AS HOT AS SUN'S SURFACE NOW PRODUCED AT G.E.'S AEROSCIENCE LAB

New "Water Arc" Advances Nose Cone Technology at Missile & Ordnance Systems Department of General Electric

When MOSD became prime contractor for ICBM Nose Cone development, engineers and scientists here were faced with the necessity of creating not only new systems concepts, new components, new materials and new fabrication techniques, but also the *very tools and facilities to evaluate them.*

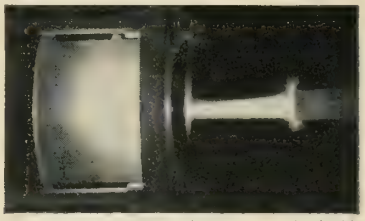
Meteors may melt on entering the earth's atmosphere, but the relatively thin-skinned nose cone must come through in full functional order. To test out heat-resistant materials capable of withstanding re-entry temperatures, a new instrument was devised under the direction of the research staff of MOSD.



STABILIZED WATER ARC and G-E designed TUNNEL shown during operation. Material undergoing test is held in front of the arc orifice by means of a rod or "sting" running through the tunnel.



3,000 KW used in operating this stabilized arc and evacuation tunnel. (Shown idle.) Has ¼" nozzle diameter. Present plans call for construction of a 3" diameter model, requiring 8,000 KW for operation.



View of fluid-stabilized arc in operation. The liquid revolving inside the glass or plastic cylinder flowing at high velocity offers insulation as well as the material of which the plastic beam is composed.

...the WATER-STABILIZED ARC

How does the new water arc differ from the conventional electric arc? It is controlled–or stabilized–by a whirling blanket of water, which produces a "squeezing" effect, forcing the arc into the shape of a column. By causing a great amount of electrical current to flow across the column, extreme temperatures may be maintained continuously, subject only to the limitations of available power.

Valuable experiments are now being conducted at MOSD's Aeroscience Laboratory with the stabilized water arc. The most advanced heat-resistant materials are subjected to temperatures as high as 25,660°F–more than twice the heat of the sun's surface.

OTHER WAYS OF CREATING HYPERSONIC ENVIRONMENT AT MOSD

G.E. has built the largest, most powerful Shock Tunnel in the country in Philadelphia. Here free flight conditions in the order of Mach 20 can be matched. MOSD also utilizes a high power Centrifuge to test behavior of electromechanical and structural components under gravity loads up to 100 G's.

OPENINGS FOR MEN WHO CAN EXPLORE NEW TECHNICAL AREAS

Engineers and scientists find an ideal research environment at MOSD. They work in small groups on problems of prime scientific interest – in close contact with managers and top specialists.

Located in downtown Philadelphia, adjacent to University of Pennsylvania and Drexel Institute, it is easy to take advantage of G.E.'s Tuition Refund Plan for graduate study.

EXCEPTIONAL GROWTH OPPORTUNITIES:

Organized only in '56, MOSD has been growing phenomenally, and continued expansion is scheduled for '57. This expansion creates many opportunities to rise to positions of higher responsibility and income level. All of the managers of technical groups are themselves engineers or scientists and the majority have come up from within this or other departments of General Electric.

YOUR INQUIRIES INVITED:

If you are a Graduate Engineer or Scientist and have experience in these or related fields:

MATERIALS AND PROCESSES • AERODYNAMICS • AEROPHYSICS • THERMODYNAMICS • ELECTRICAL DESIGN • ELECTRONIC OR ELECTROMECHANICAL COMPONENT DESIGN • STRUCTURAL DESIGN • STRESS ANALYSIS • DATA PROCESSING • SYSTEMS • SYSTEMS TEST • FIELD TEST • VIBRATION • INSTRUMENTATION • CONTROLS • GROUND SUPPORT EQUIPMENT DESIGN • TECHNICAL WRITING • ARMING AND FUZING • INERTIAL GUIDANCE

...send us your resume or, if you prefer, write us for a convenient application form.

Your resume will be carefully reviewed by the MANAGERS *of our various technical components. If qualified, you will be invited to visit our offices and discuss the work we are doing directly with the managers with whom you would be working. All communications will be entirely confidential.*

Mr. John Watt, Professional Placement, Room 590-6

MISSILE & ORDNANCE SYSTEMS DEPARTMENT

GENERAL ELECTRIC

1617 Pennsylvania Boulevard, Philadelphia 3, Pennsylvania

Group, which comprises approximately 50 people, will go to the San Bernardino Air Materiel Area where Col. Philip B. Foote will be designated as Deputy Commander for Ballistic Missiles. Brig. Gen. Ben. I. Funk will remain as overall Ballistic Missiles Weapon System Manager. No successor to Col. Foote as Commander of Maywood has as yet been named.

In his new assignment, Col. Foote will report to Gen. Anderson and receive directional control from Gen. Funk.

Staff and operating elements of the San Bernardino Air Material Area under the command of Gen. Anderson will render all necessary services to the Ballistic Missiles Weapon System Management contingent when it moves to San Bernardino.

Maywood Air Force Depot will continue to provide administrative services for the time being for the Ballistic Missiles Office at Inglewood in areas of personnel support, accounting, statistical services, transportation, legal advice, and security clearance.

$20 Million Navy Contract or Terrier Launchers

Navy has placed two contracts totalling $20 million with Northern Ordnance, Inc., Minneapolis, Mich. for *Terrier* Launching equipment. This gear is to be installed on the aircraft carriers *Kitty Hawk* and *Constellation,* as on a nuclear powered guided missile cruiser and a new class of guided missile frigate.

Beckman Forms Missile Subsystems Group

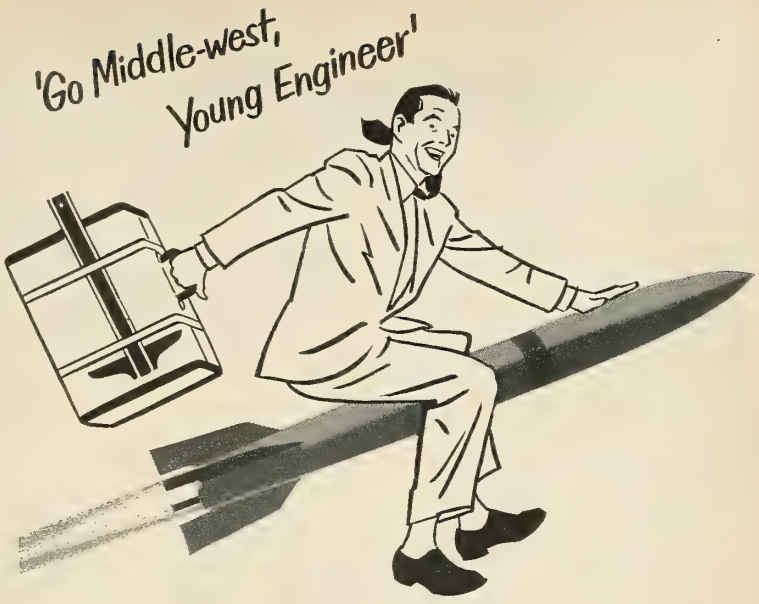
Beckman Instruments, Inc. has announced formation of a new contract engineering department in its Helipot Division. Group will be headed by Frederick Marsh under technical director O. C. Bixler.

Role of the new department will be specialization in design and production of electro-mechanical subsystems for aircraft and missiles.

New Martin *Matador* Announced by AF

The US Air Force has announced that the Martin *Matador* ground-to-ground tactical missile presently in operational use is being replaced by a new, improved version of the missile.

The TM-61C incorporates a vastly improved guidance system, designed and developed by the Martin Co. Range



FOR THE FINEST JOB OPPORTUNITIES IN THE GUIDED MISSILE FIELD!

Yes, it's a fact. At Bendix Guided Missiles you'll enjoy living in an attractive community convenient to metropolitan areas and recreational centers, with experiencing job opportunities unrivalled in the guided missile industry.

As prime contractor for the vitally important Talos Missile, Bendix engineers are engaged in the widest possible range of missile work and enjoy unusual advancement opportunities.

There is no question about it—guided missile engineering is definitely the newest and most modern business, and, logically, the best future for engineers is working with a prime contractor on one of the nation's most important missile projects.

So that you may investigate thoroughly the many advantages of becoming a Bendix Guided Missile engineer, we have prepared a thirty-six-page booklet giving the detailed story of the function of the various engineering groups, such as ram-jet propulsion and hydraulics, guidance, telemetering, steering intelligence, component evaluation, missile testing, environmental testing, test equipment design, system analysis, reliability, and other important engineering operations.

If you'd like to combine the advantages of living in the Middle West and an unparalleled chance for professional growth with one of the world's foremost missile builders, just mail the coupon today for your copy of the booklet "Your Future in Guided Missiles".

Bendix—prime contractor for the TALOS MISSILES



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Gentlemen: I would like more information concerning opportunities in guided missiles. Please send me the booklet "Your Future In Guided Missiles".

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GET THE FACTS about Solar and your triple opportunity...and get them now! Solar currently offers an exceptional opportunity for you to advance rapidly. A new creative engineering group is now being formed for a challenging new project in guided missiles. Many openings also exist in Solar's fast-moving gas turbine programs. The growth potential is tremendous . . . with commensurate rewards in advancement.

Another important advantage is this: you don't get lost in the crowd at Solar. It is a medium-size company (2800 people in San Diego) that has grown steadily since 1927. Personnel policies are advanced, including a profit sharing retirement plan.

Another advantage at Solar is the pleasure of living in California climate at its best. San Diego is warm and sunny the year around, with unmatched recreational and cultural facilities.

For brochure, write to Louis Klein, Dept. E-201, Solar Aircraft Company, 2200 Pacific Highway, San Diego 12, Calif. Why not also send along a resume of your qualifications and education?

SOLAR
AIRCRAFT COMPANY
SAN DIEGO
DES MOINES

of the *Matador* will be substantially increased over the original version according to Martin, enabling a much deeper penetration behind enemy lines and use over wide expanses of water. Traffic capabilities—the ability to control more than one missile in the air at the same time—will be greater, thus making the firepower of a missile squadron much stronger. Accuracy with the new guidance system will be improved.

The system provides complete all-weather operation of the missiles. One of the most important improvements in the TM-61C guidance system is its high resistance to electronic countermeasures. As in other *Matador* missiles, the TM-61C can be launched from rough inaccessible terrain, by the use of rugged, highly mobile launching platforms.

The TM-61C is 39.6 feet long, 54 inches in diameter and has a wing span of 28.7 feet. Operating at speeds of more than 650-miles-an-hour, the missile is capable of altitudes over 35,000 feet. The Martin Co. is producing this version of the *Matador* under an Air Force Production Contract at an approximate cost of $60,000 per missile.

Heath Breaks Ground For New Plant

Ground has been broken for the construction of a new 142,000 square foot plant for Heath Co., manufacturer of electronic equipment in kit form, Robert Erickson, president, announced recently Heath is a subsidiary of Daystrom, Inc.

The modern one-story building will house all of Heath's operations and, upon completion, will be one of the largest plants in the nation devoted to specialized direct mail selling. It will occupy a 16 acre tract in St. Joseph. Mich.

Facilities in the new plant will include specialized equipment for handling mail orders, a product research department with a new anechoic chamber for research with all types of sound equipment and a branch US Post Office.

The company presently operates in six different locations in the Benton Harbor area. Francisco and Jacobus, New York, are the architects.

M-H Reports High Earning

Minneapolis-Honeywell Regulator Co. reports highest first quarter sales and earnings in its history. Sales increased to $76,307,511, compared to $58,166,724 last year.

AN FITTINGS

Stainless, Aluminum, Brass, Steel. All sizes—immediate delivery from world's largest shelf stock. Buy direct from manufacturer. Lower prices—quicker service. Send for free wall charts showing complete line of AN Fittings.

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Largest rocket and satellite exposition ever was sponsored by the American Rocket Society and held at the Sheraton Park Hotel in Washington, April 3-6, in connection with the Society's Spring Meeting. Above is a glimpse of Allied Chemical's booth. Most of the major propellant manufacturers were represented.



Bell's Howard Jansen, right, proudly demonstrates liquid rocket pump to Rocket Society member Darrell C. Romick.



William R. Roennau of the National Capital Section of the American Rocket Society pays visit to Aerojet-General booth. Washington representative, Robert Hirsch, right, was on hand demonstrating Aerojet products.



The three Services and NACA had interesting booths, illustrating their missile efforts and their support on the VANGUARD program.



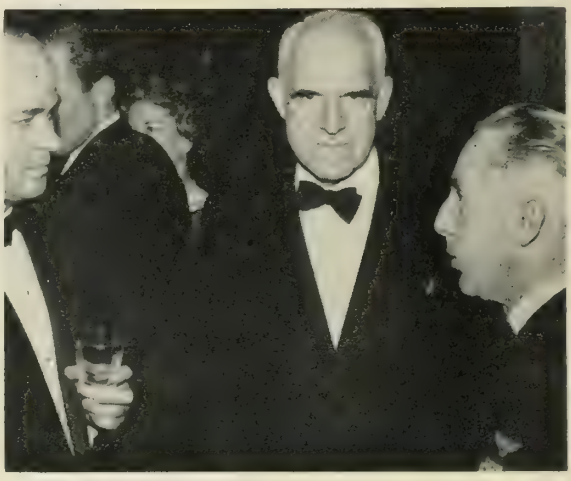
Among the many materials exhibitors was HAVEG Corporation, displaying their high-temperature insulation materials for missiles and rockets and other applications. Exposition was first of its kind and it was one of the more popular features of the ARS Spring Meeting. The exposition was not open to the general public. Why not?



ARS Spring Meeting hosts, Mrs. Jean Bergaust, Chairman of the National Capital Section's Auxiliary and National Capital Section President, Erik Bergaust, welcome special guest Jimmy Stewart to cocktail party the first day.



Rear Admiral Rawson Bennett, Chief of Naval Research, chats with fellow satellite enthusiasts. Left, Dr. John P. Hagen, and Mrs. Kurt R. Stehling. Right, Dr. A. F. Spilhaus and Kurt R. Stehling.



Rear Admiral John E. Clark, Navy's No. 1 missile man, right and Dr. Thomas Hope Johnson of the Atomic Energy Commission, talk with the Rocket Society's Executive Secretary, Jim Harford, left.

ARS Spring Meeting banquet was held in Sheraton Hall the last day of the meeting. Alan T. Waterman, Director, National Science Foundation, left, at the head table with Meeting Chairman, Andrew G. Haley; guest speaker Athelstan F. Spilhaus, Dean, Institute of Technology, University of Minnesota; and Comdr. Robert C. Truax, ARS National President.





Major General Patrick J. Ryan, right, who gave the Invocation at the banquet, converse with The Reverend Edward L. R. Elson, who gave the Benediction.



ARDC's Brigadier General Don R. Ostrander and Mrs. Ostrander at head table reception with Grand Central Rocket Co. president, Charles Bartley.



Busy National Capital Section Vice President, Robert Hirsch of Aerojet, right, never stayed anywhere more than a few minutes, his duties ranging from entertaining in Aerojet's suite to supplying press typewriters.



Mr. Rosel H. Hyde, Commissioner, Federal Communications Commission, left, with Commissioner Robert T. Bartley, and Dr. Alan T. Waterman, right.



Washington personality Col. M. Robert Guggenheim, right, had many points to stress during his lively conversation with Commissioner Bartley at banquet.

New ARS Fellow Member Rear Admiral Rawson Bennett, Chief of Naval Research, left, with National Capital Section's Erik Bergaust, m/r Managing Editor; Army Engineer and Fort Belvoir Commanding General David H. Tulley and ARS Program Chairman, Kurt R. Stehling, Naval Research Laboratories' VANGUARD propulsion head.





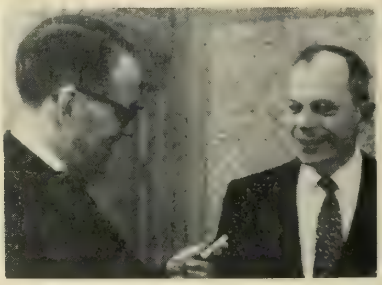
ARS Spring Meeting banquet was opened in typical Washington style, a color guard marching in with drums beating. The presence of guard, which included one representative from each service, symbolized the importance of missiles to our integrated defense system.



Popular feature was introducing Washington's Cherry Blossom Queen, her court and escorts to the ARS members at the banquet. The meeting was held during Cherry Blossom Week.



As usual, making the rounds of the hospitality suites was tough. Traditionally, Chrysler's headquarters, where Paul Stewart (left) was host, bristled with rocket engineer visitors. . .



. . . and such talented ambassadors as old-timer Lovell Lawrence, left, who said this was "the finest meeting the Rocket Society had ever put on" and should be held annually.



One of the most popular social functions was sponsored by Harvey Aluminum Company. At swanky reception, Harvey's Director of Research and Development, G. Howard Teetor, right, with head of company's Washington office, Keith Linden, welcome guests. Left, ARS' two Bob's: Truax and Hirsch.

The Dean himself, Dr. Theodore von Karman, talks space to Aircraft Industries Association's Jean Ross Howard at Harvey reception.



Rear Adm. John Clark congratulates Bob Truax on a fine meeting. "Thanks, and come again!" Next meeting San Francisco, June 10-13.



people

Lt. Gen. Laurence C. Craigie, former commander of the Allied Air Force in Southern Europe, has joined American Machine & Foundry Co. as asst. to the defense products group executive, in charge of long range planning.

A. V. Cleaver, chief engineer of the Rocket Division of de Havilland Engine Co., has joined the Aero Engine Div. of Rolls-Royce Limited as asst. chief engineer to supervise engineering of rocket motor projects.

Robert M. Hawley has been appointed director of sales and customer relations for Bell Aircraft Corp.'s Weapon Systems Division.

William G. Alexander was named chief engineer at the San Diego plant of Stromberg-Carlson, a division of General Dynamics Corp. He was formerly manager of the high resolution radar section at Westinghouse Electric Corp.'s Air Arm Div.

Paul Frankfurt has been appointed information services officer at the Ballistic Missiles Office of Air Materiel Command.



FRANKFURT

Jack Wright has been promoted to Manager of The Garrett Corp.'s Aero Engineering Div.

Haywood C. Smith, formerly manager of the Raleigh Laboratory of American Machine & Foundry Co., has been appointed technical manager, research and development dept., office of the vice president-engineering. He will be responsible for planning and directing new product development for all lines.

Andrew H. Bergeson, vice president-engineering at Stromberg-Carlson, is returning to Washington, D. C. to serve as vice president in charge of the capital city office.

Thomas Allinson has been elected vice president of marketing of Daystrom, Inc.

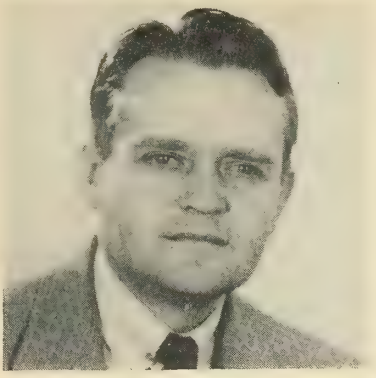
John R. McLeod, formerly with the Office of Naval Research, has been appointed manager of public relations for the Research and Advanced Development Div. of Avco Mfg. Corp.

J. W. Stack was named director of sales and contracts for the Milwaukee plants of AC Spark Plug Div. of General Motors. He succeeds **Howard W. Brandt,** who is leaving AC to go into business.

Sherman M. Fairchild, founder and board chairman of Fairchild Camera and Instrument Corp., has been elected president.

Robert P. Gira, general contracts manager for Topp Industries, Inc., has been elected a vice president.

John W. Johnson, formerly director of advertising for Chance Vought Aircraft, has been named director of the advertising and public relations department in a reorganization move.



JOHNSON

Richard W. Powell was named asst. manager of the Avionics Div., Aerojet-General Corp.

Dr. Marshall G. Holloway heads the new Nuclear Energy Products and Erco Division of ACF Industries, Inc.

Charles E. Burns has joined the Ralph M. Parsons Co., Los Angeles, as manager, Aircraft & Missiles Dept., Project Development Div.

Frank R. Carver will head Hughes Aircraft Co.'s radar development dept.; E. E. Herman will head radar systems dept.; **John C. Bailey** has been named head of scientific and general recruitment for the systems development laboratories.

Frederick A. Henry has joined the Associated Missile Products Corp. as staff asst. to the general manager.

Ronald Smelt has been named director of the New Design Office in the Research and Development Branch of Lockheed's Missile Systems Division.

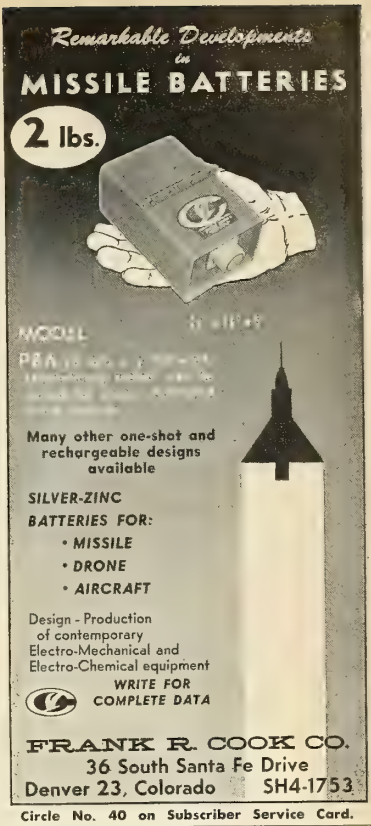
Alfred Schaff, Jr. has been named manager of Aerojet-General Corp.'s Test and Field Service for the Solid Rocket Plant at Sacramento.



SCHAFT

Joseph M. Johnston has been appointed operations supt. of instruments and components for The Victoreen Instrument Co.; **William A. McCarthy** was named sales manager for the company.

Norman P. Hays will head the new eastern office of Autonetics, div. of North American Aviation, in Washington, D.C.



Circle No. 40 on Subscriber Service Card.

*LOX GRADE KEL-F**

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people

John C. Howe has been appointed district sales manager in the Dayton office of General Electric's Light Military Electronic Equipment Dept.

Donald M. Allison, Jr. has been named asst. manager of military products of Radio Div., Bendix Aviation Corp.

Thomas L. Douglas has been appointed senior sales engineer, Finn Aeronautical Div., T. R. Finn & Company, Inc.

Robert C. Gibson has been appointed asst. weapon system manager at Lockheed Missile Systems Div.

Dr. Royal Weller, chief scientist at Naval Air Missile Test Center, Point Mugu, Calif., joins Stromberg-Carlson as vice president-engineering.

Kenneth P. Bowen, formerly vice president-manufacturing and material for Northrop Aircraft, has been appointed gen. manager for Summers Gyroscope Co.

Mr. G. Norris Shaw, formerly with Navy's BuAer in Washington, joins Temco Aircraft Corp. as senior military liaison engineer.

Donald L. Blessing has been named general manager of the Metal Products Div. of Modglin Co., Inc.

Donald C. Webster, chief engineer of Librascope, Inc., has been elected vice president.



WEBSTER

Maurice A. Broner has been named managing editor of the Journal of Astronautics, official organ of the American Astronautical Society, Inc.

David W. Moore was named manager of Servomechanisms' new components division.

Weaver Barnett has been named technical group engineer and **G. Norris Shaw** has been appointed senior military liaison engineer for Temco Aircraft Corp.

Robert J. Brown is sales manager for the Mincom Div. of Minnesota Mining and Mfg. Co.

Fred H. Edgar has joined Olin Mathieson Chemical Corp. as sales manager, Detroit-Cleveland Div. for Olin Aluminum; **Lt. Cmdr. Enoch D. Blackwell** has joined the contract administration staff of the High Energy Fuels Organization of Olin Mathieson.

Andrew McMillan has been appointed sales engineer for Narelco products by the Instruments Div., Philips Electronics, Inc.

Marshall P. Bearce has been named asst. to the general manager, public relations div., Elgin National Watch Co.

Don MacIver is the new public relations mgr. for Texas Instruments Inc.

John D. Saint-Amour has been elected president of Assembly Products, Inc. **Robert H. Pugsley** was elected vice president, sales mgr., and director.

Michael Gerald O'Neil was elected vice president and exec. asst. to the president of General Tire & Rubber Co.

John K. Gossland has been appointed exec. vice president and general manager of Electromation Co., Inc.



GOSSLAND

George J. Costello has been appointed mgr. of the ordnance products dept. of The W. L. Maxson Corp.

William V. Crowley has been named sales mgr. for the Western Div. of ALWAC Corp.

Dr. John C. Clark has resigned as associate leader of the Test Div., Los Alamos Scientific Laboratory, to become staff asst. to the manager of Convair-Astronautics.

J. B. Van Der Werff has been appointed chief engineer, Gladden Aircraft Products Corporation.

Norman C. Anderson, manager of the Photoconductor-Transistor Div. of Electronics Corp. of America, has been appointed vice president of the division.



ANDERSON

Daniel Darnell, Jr., former North American Engineering test pilot, has been appointed chief of customer relations for Autonetics, a division of North American Aviation, Inc.

Dr. Eugene Miller, formerly chief of research laboratories at Redstone Arsenal, has been appointed director of research and development of solid propellants in the Explosives Div. of Olin Mathieson Chemical Corp.

Chandler C. Ross and **Robert B. Young** have been elected vice presidents of Aerojet-General Corporation in charge of engineering and the Liquid Rocket Plant, Sacramento, respectively.

missile literature

TUBULAR PARTS. Facilities for design and production of specialized metal tubular parts are described in Bulletin No. 2056 issued by H&H Machine Co.

Circle No. 100 on Subscriber Service Card.

SILICONE PRODUCTS. Illustrated catalog prepared by General Electric Co.'s Silicone Products Dept. describes more than 115 different applications for silicones it now produces.

Circle No. 101 on Subscriber Service Card.

HIGH TEMPERATURE RESEARCH. New continuous heat source providing controlled temperatures up to 15,000°K is fully illustrated in brochure issued by Plasmatron. Process described is development of Giannini Research Laboratories (m/r, March 1957).

Circle No. 102 on Subscriber Service Card.

TEFLON INSULATION. American Super-Temperature Wires, Inc. has published a 30-page catalog describing Teflon insulated wires and cables for high temperature applications.

Circle No. 103 on Subscriber Service Card.

EXPLOSIVE VALVES. New brochure issued by Conax Corp. describes its series of explosive actuated valves for aircraft and missile use.

Circle No. 104 on Subscriber Service Card.

THRUST STANDS. Series of three brochures available from Hunter-Bristol Corp. describes thrust measuring units for complete jet aircraft or missiles; for jet engines; and, for rocket-powered test systems including test sleds, monorail and free-flight vehicles.

Circle No. 105 on Subscriber Service Card.

OPTICAL TOOLING. Specialized optical tooling and testing equipment available from Keuffel & Esser Co. are described in new 17-page bulletin.

Circle No. 106 on Subscriber Service Card.

POWER RECTIFIERS. The Christie Electric Corp. has announced the availability of a new bulletin covering their three lines of D C Power Rectifiers.

Circle No. 107 on Subscriber Service Card.

WIRE WOUND RESISTORS. Comprehensive data on construction, characteristics, coating, winding, insulation identification, mechanical strength, terminals and brackets—detailed charts and graphs, is given in a 12 page booklet by International Resistance Co.

Circle No. 108 on Subscriber Service Card.

POTENTIOMETERS MEASUREMENT. Helipot Corp.'s new 30-page booklet takes up a practical approach to predicting, measuring and compensating for quadrature voltage and phase shift in copper-mandrel potentiometers used in AC circuits.

Circle No. 109 on Subscriber Service Card.

WELDED BELLOWS. Belfab Corp. has published an 8 page catalog on welded bellows in stainless steel and similar alloys.

Circle No. 110 on Subscriber Service Card.

AMPLIFIER. 400 and 60 cycle magnetic amplifier data and specifications are given in a 16 page Product Catalog from Litton Industries.

Circle No. 111 on Subscriber Service Card.

JOINTS. Rubber, neoprene and Teflon-lined expansion joints their construction, sizes and uses are explained in a bulletin issued by The Garlock Packing Co.

Circle No. 112 on Subscriber Service Card.

VIBRASWITCH. A device that protects rotating and reciprocating machinery by anticipating any malfunction, is described in a four page bulletin available from Fielden Instrument Division of Robert Shaw-Fulton Controls Co.

Circle No. 113 on Subscriber Service Card.

TRANSFORMERS. A new four-page brochure describing a line of military and special commercial transformers has just been released by Laboratory for Electronics, Inc. and describes, high power pulse, hermetically sealed military and open type military, subminiature binary and toroids.

Circle No. 114 on Subscriber Service Card.

HITEMP WIRE. Characteristics of Altemp Teflon high-temperature, insulated hook-up wire and contained in Catalog T-1 available from Alpha Wire Corp.

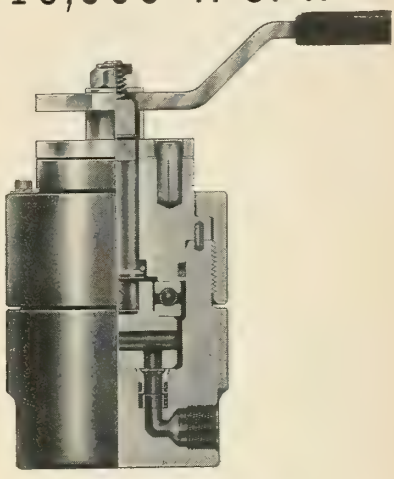
Circle No. 115 on Subscriber Service Card.

SOLENOID COIL. Folder 210-3 issued by Hays Manufacturing Co. describes its "Kast-Coil" waterproof, shock-resistant solenoid coil.

Circle No. 116 on Subscriber Service Card.

NEW 'SHEAR-SEAL' VALVE

FOR 10,000 P. S. I.



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26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

• • Missile Literature

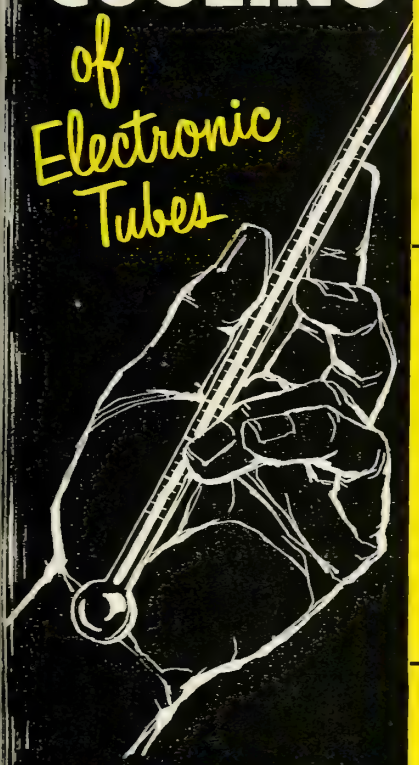
100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125

• • New Missile Products

200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224
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LIQUID COOLING of Electronic Tubes



WITH Eastern COOLING UNITS

By a sustained program of research, Eastern continuously extends the uses of the latest units in electronic tube cooling, pressurizing electronic equipment, and pumping fuels and hydraulic fluids. Research and testing laboratories, a model shop, and three manufacturing plants provide the specialized equipment and manpower to turn out fully qualified units to meet appropriate government specifications.

From our extensive line of existing units, adaptations of these units, or completely new designs, Eastern can provide equipment to handle your project well. Your inquiry is welcomed.

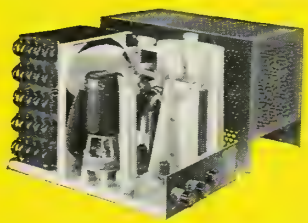
EASTERN INDUSTRIES, INC.
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Eastern Cooling Units provide coolant liquid for maintaining within safe operating temperature limits liquid cooled electronic tubes or similar devices. The units are completely self-contained and usually comprise such components as heat exchangers, fans or blowers, liquid pumps, reservoirs, flow switch, thermostat, etc.

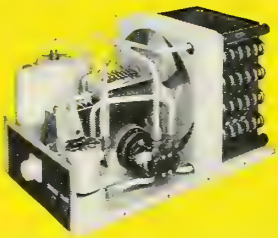
Cooling units can be modified as required for varying conditions encountered in land or sea as well as aircraft service. Almost all units are designed to meet such specification as MIL-E-5400 and MIL-E-5272.

The units shown below are intended only to illustrate the varying requirements which can be satisfied. By utilizing fairly standard components and designs based on broad experience in this field, Eastern is able to provide at minimum cost equipment exactly suiting a specific requirement.

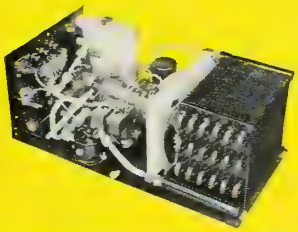
Eastern welcomes your consultation on liquid cooling problems ranging from 200 to 20,000 watts dissipation.



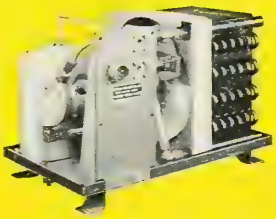
MODEL MB-175, TYPE 200 DISSIPATION: 2,000 watts. ALTITUDE RANGE: sea level to 50,000 feet. POWER REQUIRED: 28 volts D.C. WEIGHT: 25 pounds. SIZE: 10" x 15-15/16" x 10¾" high.



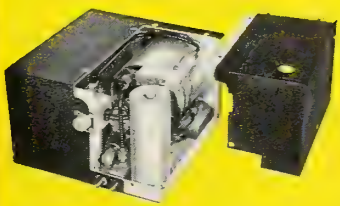
MODEL E/HT-205, TYPE 200A DISSIPATION: 1600 watts. ALTITUDE RANGE: sea level to 5,000 feet. POWER REQUIRED: 28 volts D.C. WEIGHT: 25 pounds. SIZE: 10" x 21" x 10" high.



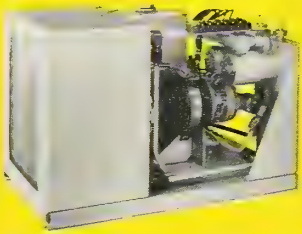
MODEL MB-177, TYPE 202 DISSIPATION: 1700 watts. ALTITUDE RANGE: sea level to 50,000 feet. POWER REQUIRED: 110 volt, 400 cycle, 3 phase. WEIGHT: 27 pounds. SIZE: 10" x 19 15/32" x 7⅝" high, per JAN-C-1720A, size B1-D1.



MODEL E/HT-210, TYPE 200 DISSIPATION: 1500 watts. ALTITUDE RANGE: sea level to 10,000 feet. POWER REQUIRED: 208 volts, 400 cycle, 3 phase. WEIGHT: 35 pounds. SIZE: 11¼" x 19½" x 12½" high.



MODEL E/HT-200, TYPE 201 DISSIPATION: 1,000 watts. ALTITUDE RANGE: sea level to 50,000 feet. POWER REQUIRED: 28 volts D.C. WEIGHT: 14½ pounds. SIZE: 10" x 10" x 6" high.



MODEL NO. 5-A DISSIPATION: 1,000 watts. ALTITUDE RANGE: sea level to 5,000 feet. POWER REQUIRED: 100 to 110 volts D.C. WEIGHT: 10 pounds. SIZE: 7⅞" x 13½" x 9-1/16" high.

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m/r JUNE, 1957



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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

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NUCLEAR POWER AND ION PROPULSION

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Magazine of World Astronautics

June, 1957 Volume II, No. 6

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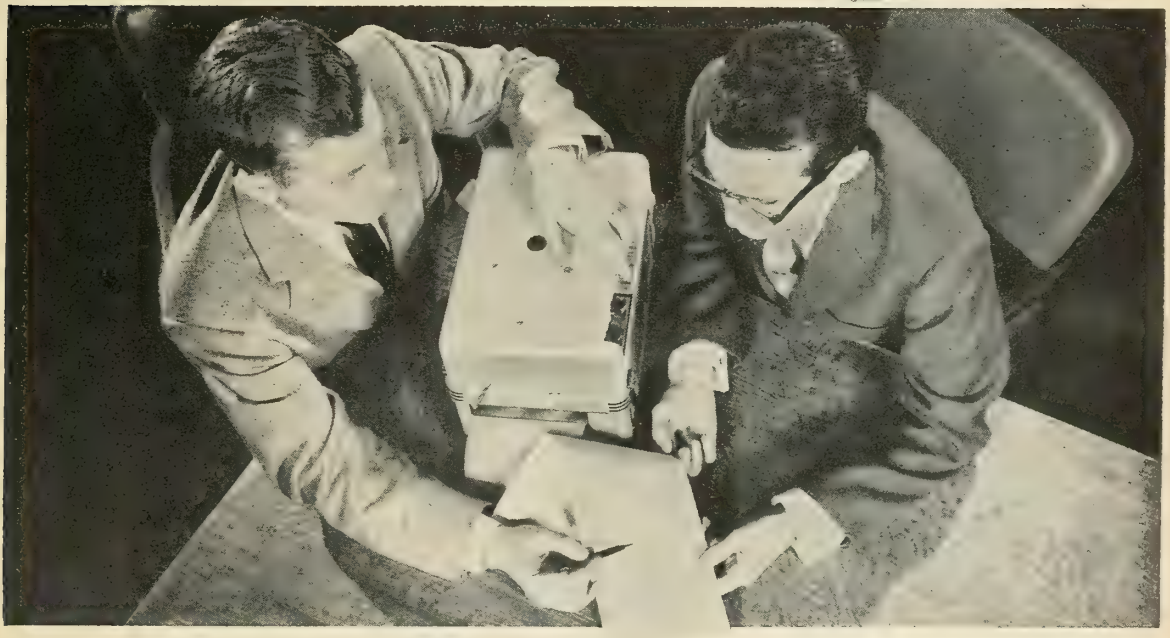
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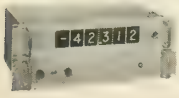
But versatility is only part of the story. These new modules also boast dramatically new engineering specifications, fully transistorized circuits and numerous other features which were incorporated as the result of our experience with more than 1,000 digital instruments in the field.

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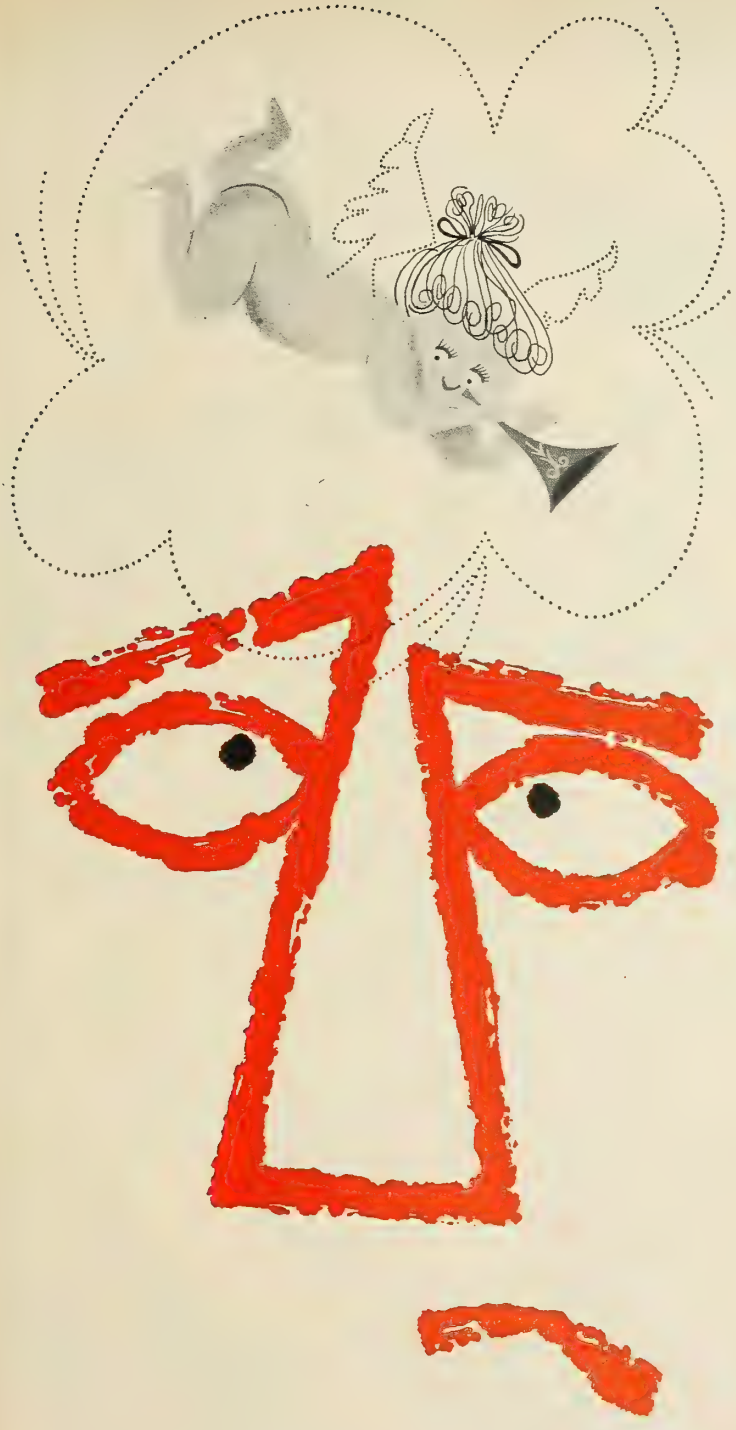
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Our Special Products Division designs and builds launching stands, test towers, ground-movement vehicles, and storage devices for *almost* any size missile, anywhere.

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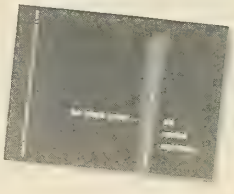
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This is Not the Time to Cut

Three years ago the U.S. did not have a ballistic missile and none was in sight.

Just lately the Army's intermediate range ballistic missile, *Jupiter*, went the full distance of its immediate objective—1500 miles. It was the first long range U.S. ballistic missile to do so.

The USAF inter-continental ballistic missile, *Atlas*, sits on its launching pad, ready for a first try at the 5000-mile mark. The more sophisticated *Titan* has cut months from its schedule and is reported to be almost as far along as *Atlas*.

Within the next fiscal year these super-weapons should begin to be fed into America's arsenal. Without doubt they represent the greatest contribution to deterrent military power since the original concept of the USAF Strategic Air Command a decade ago.

This state of the ballistic missile art and science has been achieved in fewer than 36 months from the original go-ahead. It is truly a remarkable and commendable record.

But—

Just at this critical time when the results of a crash program of achievement are being realized, the entire missile program is endangered by an economy ax wielded by Congress.

The same Congress that "viewed with alarm" and gave its wholehearted all-out approval to the crash missile program only several years ago, is now in the mood to chop off the program during its crowning period of producing tangible results.

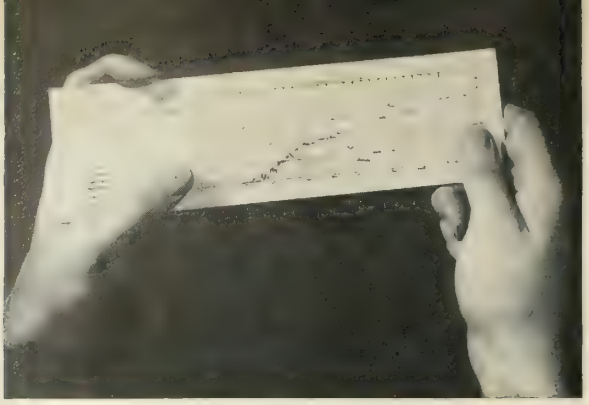
The same Congress that urged duplication of effort in order to obtain maximum results with greatest speed, is now concerned about overlapping of missile efforts.

Industry accepted the challenge three years ago. And it was only through duplication—permitting several simultaneous approaches to the problem—that ballistic missiles have reached their present stages of development in such a short space of time.

There are times when economy is extremely short-sighted. This is one of them. It would be foolhardy to trim at this crucial juncture of missile development. It would be like calling off a race in the last tenth of a mile simply because one or two horses stopped running.

Except that the missile race is not a horse race. This is no sports event. We are participants in a world-wide struggle for survival. And the struggle for survival leaves no margin of error for whims or budget-cutting for political purposes. There is no margin left in this struggle for anything except actual achievement in missile power.

WAYNE W. PARRISH



typical data presentation

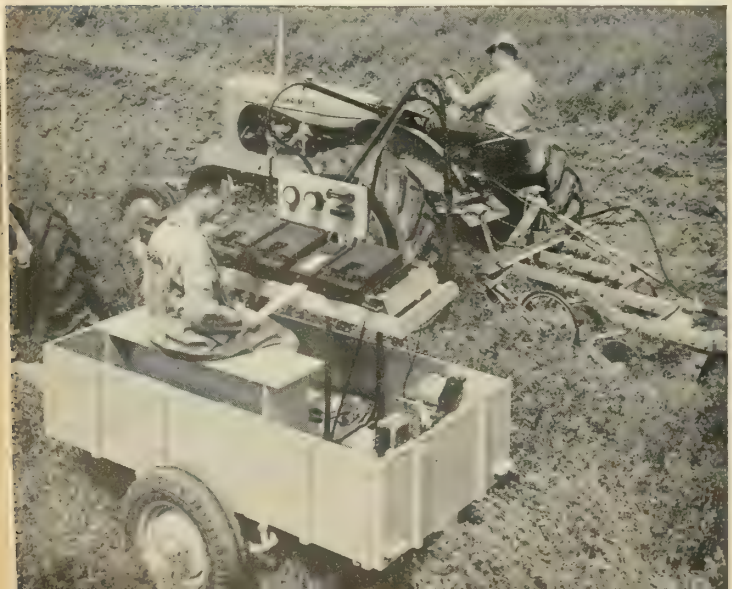
of Spectrum Recorder. Instrumentation consisted of Accelerometer, Vibration Pickup Preamplifier, and Spectrum Recorder.

CONVAIR CUTS JET LINER ENGINEERING TIME WITH AUTOMATIC SOUND INSTRUMENTATION

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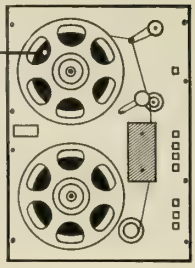
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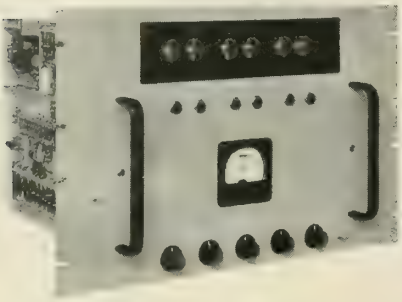
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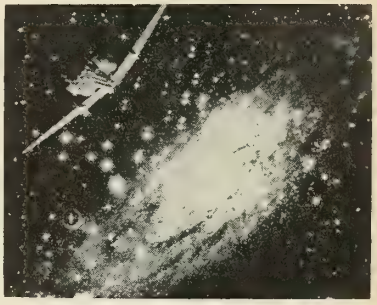
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FIRST ANNUAL ENGINEERING PROGRESS ISSUE

cover picture:



En route to another galaxy! Japanese artists Yasumasa Miyazaki and Toshihiko Sato are famous for their illustrations in the field of astronautics. The cover picture illustrates a combination chemical rocket and nuclear rocket vehicle in outer space. Other outstanding illustrations by these Japanese artists appear on pages 78, 82 and 87. They all have the futuristic look that may be indicative of tomorrow's space vehicles.

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Yasumasa Miyazaki and Toshihiko Sato, cover, pp. 78, 82, 87; Martin, pp. 39, 40; Rene St. Paul, pp. 42, 43; Krafft A. Ehricke, pp. 63, 71; SNCAN, p. 43; U.S. Army, pp. 64, 66, 67, 108, 126, 128; U.S. Air Force, pp. 118, 119; Westinghouse, pp. 73, 74; Convair, p. 88; Alfred J. Zaehringer, pp. 94, 184; Seabrook Hull, pp. 94, 103, 104, 184; Chrysler, p. 107; Boeing, p. 122.

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JUNE

Fourth International Automation Exposition and Military Automation Exposition, Coliseum, New York City, June 9-13.

ASME Semi-Annual Mtg., Sheraton-Palace, San Francisco, June 9-13.

Operations Research Conference, sponsored by Illinois Institute of Technology, IIT Campus, Chicago, Ill., June 12-14.

American Society for Testing Materials, annual mtg., Chalfonte-Haddon Hall, Atlantic City, N. J., June 16-21.

National Conference on Military Electronics, sponsored by IRE PGME, Sheraton Park Hotel, Wash., D. C., June 17-18.

IAS National Summer Mtg., Biltmore Hotel, Los Angeles, Calif., June 17-20.

Aviation Distributors & Manufacturers Assn., 29th mtg., The Broadmoor, Colorado Springs, Colo., June 23-25.

Soviet National Aviation Day, Moscow, June 24.

Federation Aeronautique Internationale, Palermo, Sicily, June 25-30.

JULY

Air Force Assn. Convention, Washington, D. C., July 30-Aug. 4.

AUGUST

IAS Naval Aviation Mtg., U. S. Grant Hotel, San Diego, Calif., Aug. 6-10.

International Ignition Conference, Bendix Scintilla Div., Sidney, New York, Aug. 20-22.

Western Electronics Show & Convention, Cow Palace, San Francisco, Calif., Aug. 20-23.

SEPTEMBER

Royal Aeronautical Society & Institute of Aeronautical Sciences, sixth International aeronautical conference, Folkstone & London, England, Sept. 1-15.

General Assembly of the International Union of Geodesy and Geophysics (IUGG), Toronto, Sept. 3-14.

ASME Fall Mtg., Hotel Statler, Hartford, Conn., Sept. 23-25.

SAE Aeronautic meeting, Aircraft production forum and aircraft engineering display, Ambassador Hotel, Los Angeles, Calif., Sept. 30-Oct. 5.

OCTOBER

National Electronics Conference and forum on electrical research, development and application, Chicago, Ill., Oct. 7-9.

Triennial Inspection of the NACA Lewis Propulsion Lab., Cleveland, Ohio., Oct. 7-10.

International Astronautical Federation, 8th Annual Congress, Barcelona, Spain, Oct. 7-12.

National Fall Convention, Society for Experimental Stress Analysis, El Cortez Hotel, San Diego, Calif., Oct. 9-11.

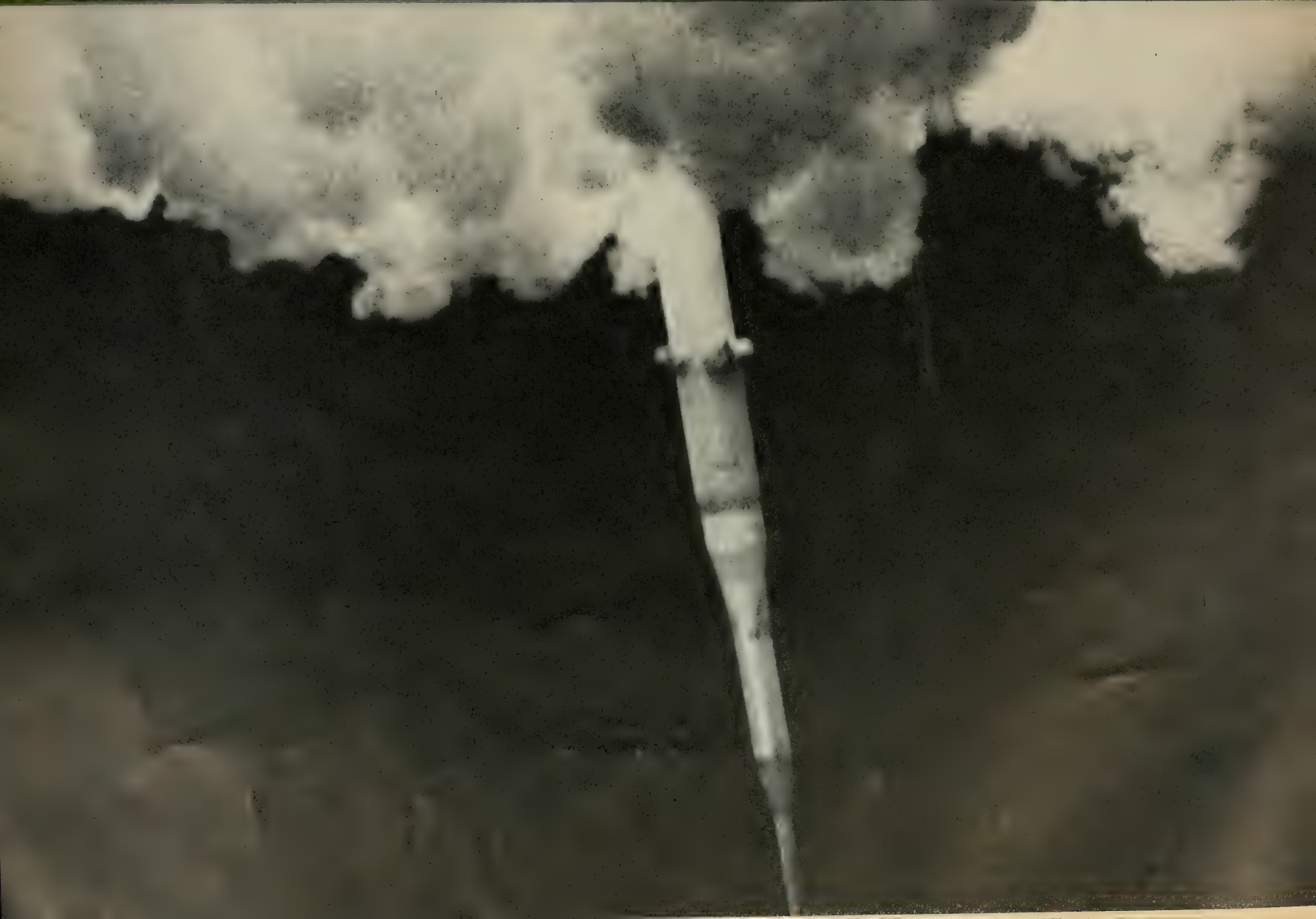
ASME Conference on New Developments in the Field of Power, Americus Hotel, Allentown, Pa., Oct. 21-23.

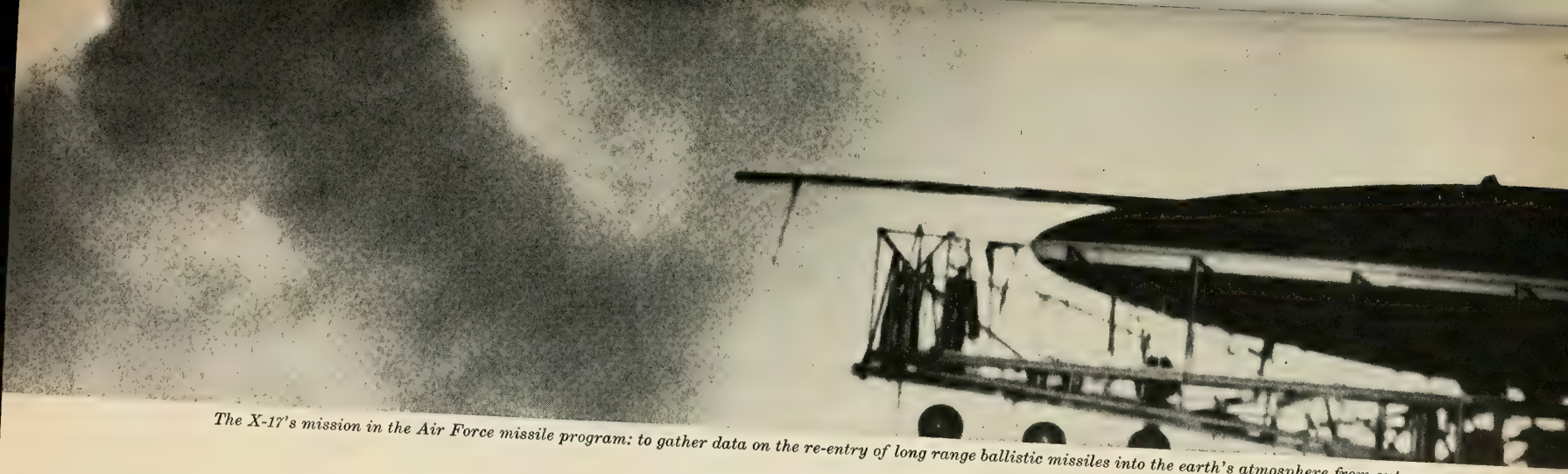
Canadian Aeronautical Institute/IAS Meeting, Montreal, Canada, Oct. 21-22.

Computer Applications Symposium, sponsored by Armour Res. Foundation, Hotel Sherman, Chicago, Ill., Oct. 23-24.



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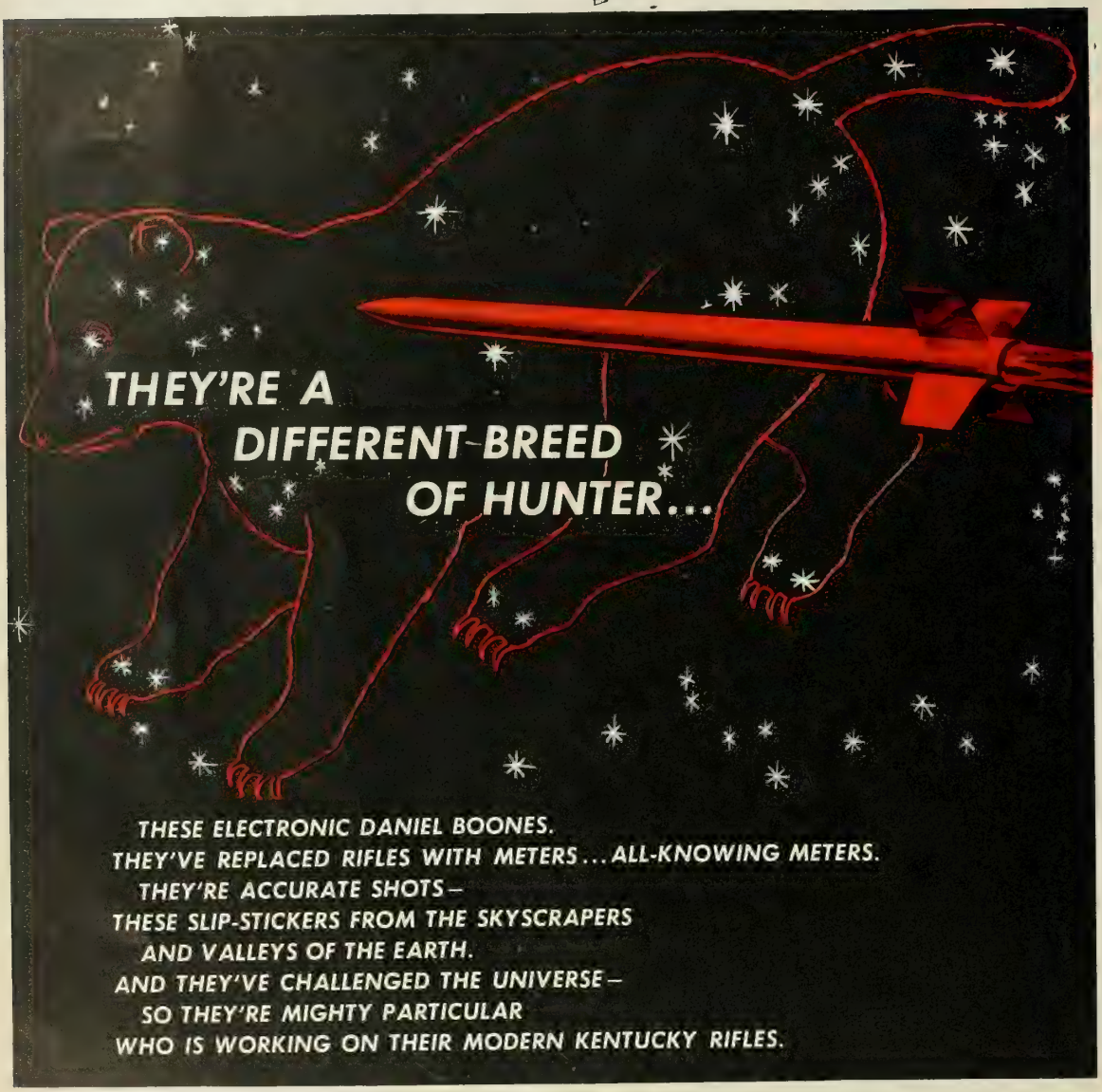
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letters

Would-Be Rocket Engineers Again

To the Editor:

I am concluding my junior year in high school and have been greatly interested in rockets for about 6 years. (My highest dream is to some day be along on the first flight to the moon or some near-by planet.)

I think I am most interested in propulsion and would like to do research on new types of rocket propulsion, or try to perfect today's fuels. I have tried to prepare myself for such work by following high school outlines for most technical or engineering schools. I am very much perplexed on deciding what to major in in college to prepare myself for work in this field.

Aeronautical engineering, physics, engineering science and chemical engineering has all been suggested to me. As a guidance project we are to write to some known expert and ask for advice on our own problem. So, after reading your book I chose you to write to. If you find time to return a letter I would like to know what special field you would suggest I study in college.

As to college I am considering MIT and hope I will be accepted. I have maintained a straight A average in all subjects and have participated in extra curricular activities, such as: baseball, football, basket ball, German Club and others.

I would very much appreciate an answer to the previous questions and if you approve my selections of colleges. Since I could only attend MIT on some sort of a scholarship, I am considering Case Institute of Technology and Carnegie Institute of Technology.

If you know of any others I would appreciate hearing of them.

David Bonn
Deshon Manor
Butler, Penna.

You are one of many thousands of American youngsters with a common problem. If you are 17 years old you can and should join the American Rocket Society as a student member. Write to them for information. The address is American Rocket Society, 500 Fifth Avenue, New York 36, N.Y. Do not hesitate to write to the universities mentioned in your letter, such as MIT and Purdue. Also, why not try Johns Hopkins? We are preparing a special issue on education and training for the missile age, to be published this fall. We hope this will be of value to you. Our personal advice—while you are waiting for the first moontrip—concentrate on mathematics and chemistry.—Ed.

Says He Thought Of It First

To the Editor:

I noted Winzen's comments on the introduction of the Balloon-Launched Rocket in 1947. In a rather science-fictionish article titled "Electronics & Airpower" which ran in the September-October-November, 1944 issues of "Radio-Craft," I made a similar suggestion. Why are not rockets lifted by balloons to 15 or 20 mile heights and then triggered off by aneroid type detonators to send them up another 10 or 20 miles.

This was probably never seen by rocket men, but it looks like it was a pretty good question at that, even though I should have said "100 or 200 miles."

Ted Powell
42 Nassau Rd.
Great Neck, L. I.

Missile Help for High Schools

To the Editor:

Under letters I notice correspondence on high school rocket courses with kudos for the University of Maryland. We have a program under way in which twelve local high schools are participating. I think it's important to interest high schools in rocket work and other scientific work and provide opportunities for them. Maybe m/r can sparkplug such projects.

The item on Page 52, about the Russian drawings of the *Mouse* satellite are of interest to me and I'm glad to know that they are giving me credit . . . Your whole series about underwater missiles is excellent and I can't praise it enough . . .

S. Fred Singer
University of Maryland
College Park, Maryland

A Need for m/r

To the Editor:

I have recently seen your magazine and I would like to let you know that I feel it is very informative and that there is a definite need for it in the missiles and rockets field.

N. E. Miller
Murphy & Miller, Inc.
1326 S. Michigan Ave.
Chicago 5, Ill.

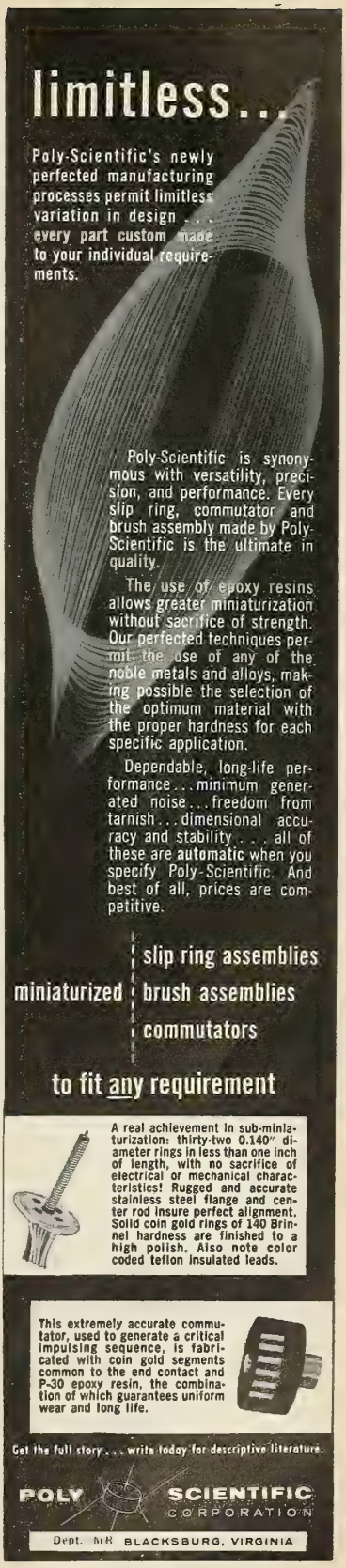
Donner and Blintzon

To the Editor:

We have followed with interest the correspondence in your journal on the subject of the acceleration in free fall of Lintz basalt. We feel obliged to draw to your attention the fact that in the particular case of this phenomenon the Russians may have scored a first. Whereas the paper of Brush, allegedly pioneering the work in this field, appeared in the Proceedings of the American Philosophical Society, Vol. 65 (April 23, 1956), we must report that in the journal Soviet Transactions on Basalt Science, Vol. 17 (April 1, 1924), not only was the constant generation of heat in Blintz basalt reported as exceeding that which is possible from radioactive effects but also the acceleration of Schmaltz basalt was recorded as having been measured at 994.4 cm/sex^2 (for samples of Schmaltz basalt 99 and 44/100 per cent pure). Furthermore, for samples of Schmaltz basalt 99 and 77/1000 per cent pure the acceleration was reported to be 997.7 cm/sex^2.

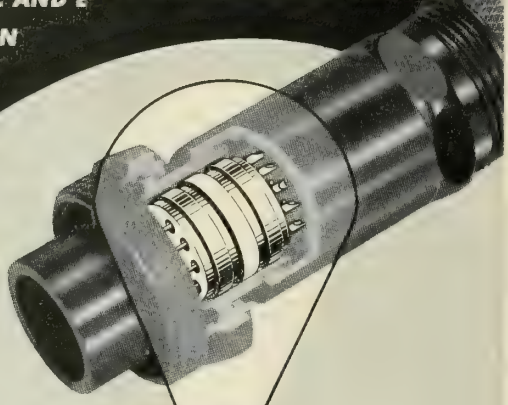
Soviet experiments on these materials were prematurely discontinued (probably due to a grave shortage of Soviet Schmaltz basalt).

It may be pertinent to record, moreover, that the writers have examined the possibility of a quantitized theory which may bear upon inertial and gravitational equivalence in the light of the reported data. We obtain a satisfactory field theory,

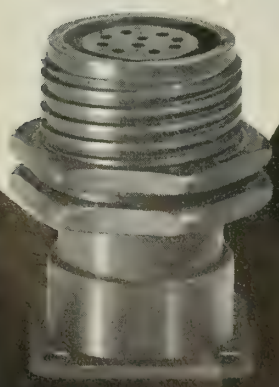


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in agreement with the experiments, provided we postulate a graviton (the Blintzon) and an anti-graviton (the Schmaltzon) for which, in the classical limit, the following results hold: First, there are equal numbers of Blintzons and Schmaltzons in the universe. Second, the equivalence principle of gravitational and inertial mass is valid except for mass in which the parity principle for Blintzon and Schmaltzons is violated. (This seems to be the case for the material used in Brush's experiments.) Third, anti-gravitation is possible only for sufficiently pure Schmaltzy material.

We are presently concerned with the corresponding calculations for Blintz basalt but are not yet prepared to communicate our preliminary results.

R. M. Baer
Dept. of Mathematics
D I. Caplan
Dept. of Physics
Purdue University
Lafayette, Indiana

We appreciate the author's interest in m/r but feel we should point out to them that in their deliberations they completely overlook the catalytic effects of a colloidal suspension of emulsified butyrates in proteinaceous-lactic acid medium which was reported by Kreplach and Bupkiss in the Journal of Comparative Oblivion, Vol. XXX, June 31, 1919 —Ed.

Anomalies on Lintz Basalt

To the Editor:

I have read all the letters dealing with Lintz Basalt with considerable interest and a bit of astonishment.

I cannot help but feel glad that your attitude with respect to the whole "anti-gravity" run is a good one. I think you will be interested in the following and I hope that this will contribute somewhat to a critical look at this question:

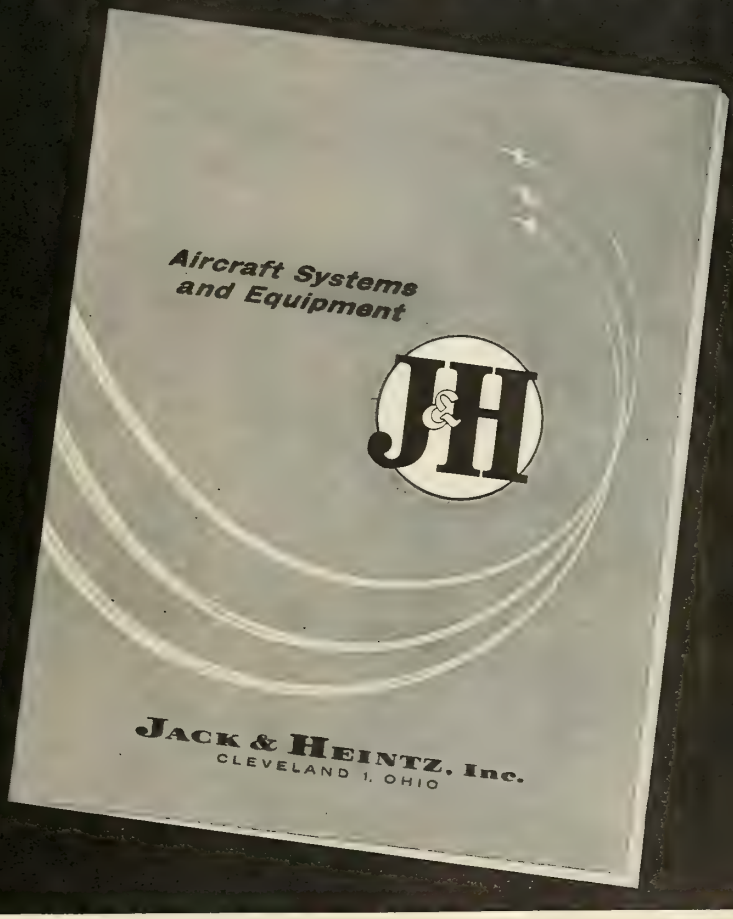
Concerning gravity—anomalies on Lintz Basalt.

For a critical consideration of such anomalies claimed to have been observed on Lintz Basalt it is, of course, sufficient to apply the Newtonian concept of gravity.

Isaac Newton in 1687 gave the quantitative relationship for gravitational interactions: $F=GMm/r^2$, where F= Force, G = 6.68×10^{-8} dyne, the universal constant of Gravitation, M= the mass of the earth, r= the earth's radius and m= the mass of the test body. The three factors, G, M and r (the minutest changes of r in experiments with pendulums or falling bodies can be ignored) are constant and can therefore be symbolized by one factor, $g = GM/r^2$. The formula for F now reduces to F=gm, which is the force of the earth on a body on its surface, commonly called weight, or seen from another aspect, a fundamental formula of mechanics. This last formula shows that the acceleration g of a falling body is determined only by these three factors, G, M and r, and is therefore independent of its mass m.

The radius of the earth is known with a remarkably high degree of accuracy. The change of g with varying altitude, respectively the acceleration g_a is given at an altitude a by: $g_a = g(1 - ka)$ where g is the acceleration at sea

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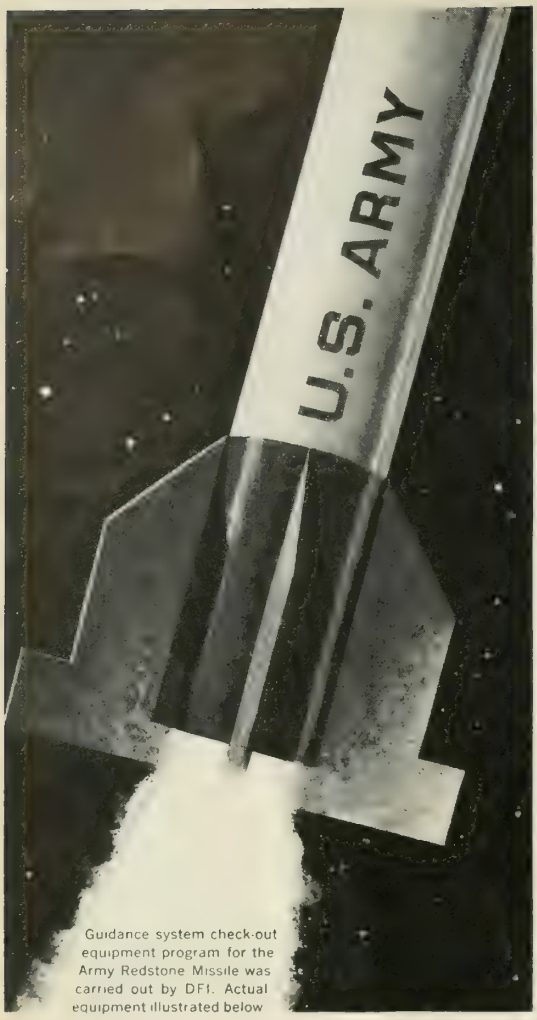
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Guidance system check-out equipment program for the Army Redstone Missile was carried out by DFI. Actual equipment illustrated below

How to pitch a perfect "strike"

. . . 200 MILES AWAY

It's tough enough to pitch a baseball 60 feet, 6 inches, and get a strike. Imagine pitching a multi-ton rocket 200 miles . . . and guaranteeing a strike every time.

It's no accident . . . Such pin-point accuracy comes from a precision-built, self-contained guidance system, developed by U.S. Army scientists and integrated into Redstone Missiles by Chrysler Corporation Missile Operation.

A very small error in guidance, though, means a very large error in target accuracy. So a precise, highly reliable test system for "guidance check-out" had to be developed.

And it's no accident that Designers for Industry was given the responsibility of producing this vital check-out system. During our 22 years, we've built a reputation for performance on many projects critical to national defense. The unusually tight schedule set by the Army for this program was met by closely coordinated teamwork between Chrysler and *DFI*.

Unusual results were achieved beyond the immediate program requirements. For example, as part of a complete A.C.-D.C. Power Supply, a special control for a standard rotary inverter was needed. This new control gives *regulation of 30 parts per million* at 400 cycles under steady load — and feed or absolute regulation of 0.05 cycles in 400 under varying load and feed.

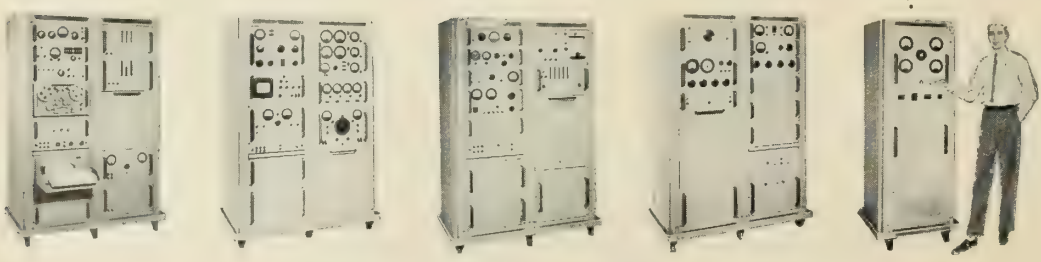
Production of such equipment has again demonstrated our ability in this and allied fields. We can offer power supplies or inverters for other applications, *including inverters for airborne uses.*

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Output: 26-32 Volt, D.C. variable; regulation 1%, ripple factor less than 1%, 0.56 KW.

115 Volt, A.C., 3 Phase, 400 cycle, regulation 0.05 cycles for varying load, 30 parts per million for "steady state", 750 VA.



Representative samples of test equipment produced by DFI

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level and k is a factor of proportionality, approximately = 3.10^{-7}, that is, if the weight of 1 kilogram is raised 1 meter, the change in weight is .3 milligrams. For weighing experiments of utmost accuracy it is therefore necessary that the two masses be arranged at exactly the same level. On the other hand, by arranging alternately the two masses at different levels, the factor k can be determined accurately.

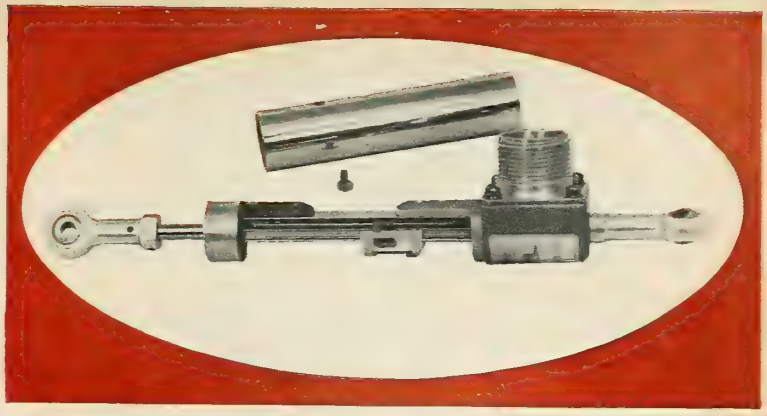
G and respectively g are determined with torsion balances (such a torsion balance was used in 1798 by Cavendish for the first determination of G), pendulums, balances and gravimeters. Gravimeters (today mainly used for geophysical explorations, e.g., of oil fields) are in principle spring balances of extremely high sensitivity, the measuring system of which weighs only some grams or fractions of a gram.

Newton showed with pendulum experiments that for a given length of the pendulum, g or the swinging time, was independent of the material of the bob. The accuracy of his experiments was about 1 part in 10. F. W. Bessel, (1), improved the accuracy of these measurements to about 1 part in 10^5 and obtained the same results, that is, no influence of the material on g could be measured. R. V. Eotvos (2) and coworkers (3) improved the accuracy of the torsion balance used by him to such a degree, that G respectively g could be determined with an accuracy of 1 part in 10^9. All his measurements showed that g is not influenced by different kinds of substances, e. g., metals, liquids, organic substances etc. Furthermore he showed that g is not influenced by the radioactivity of the test material. He too showed that the "absorption" of the earth along its axis with respect to gravitation would be less than 1/800 of the total attractional force of the earth. Q. Majorana, (4) obtained the same results.

(5) It was claimed by Ch. F. Brush, based on experiments, that the proportionality or identity between gravitational and inertial mass was not fulfilled; or what is the same, an influence of the material, for example Bismuth crystals of the test body, was present on g. However, it was shown by H. H. Potter & P. Philipps, (6), Wilson (7) and A. Berroth (8) that these claimed discrepancies or results were erroneous. Furthermore, P. R. Heyl (9) showed that the gravitational interaction of cystals: Quartz, Zirconium, Turmalin, Gypsum etc. was independent of the orientation of the different crystal axes. P. Zeeman (10) obtained the same, that is negative results, with spheres made of natural quartz crystal, P. Landolt (11) on the other hand could show that no influence existed of chemical changes on the gravitational interaction. Finally, E. W. Shaw and N. Davy (12) proved experimentally that there is no influence of temperature on the gravational interaction. The discrepancies in some of these experiments were all of a minimum magnitude, i.e. less than about 10^{-8}.

Keeping in mind these experimental facts and referring again to the two formulas, there remains only one very hypothetical possibility for the discrepancies claimed by Ch. F. Brush, and that is a change of G.

P. M. Dirac (13, 14) proposed the hypothesis that G is not a constant but undergoes a variation in magnitude with



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New construction... environment-proof performance

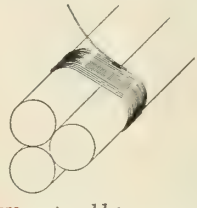
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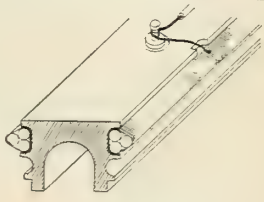
Bonded construction has simplified and ruggedized internal connections. Resistance elements and rail are bonded integrally to the frame. Made with high temperature glass insulated terminals for internal lead connections and hard soldered connections to connector pins for reliability.

New design for the brush carriage holds brush pressure accurately throughout the length of the resistance element. Withstands vibration at 25G from 20 to 2000 cps without discontinuity or excessive noise.

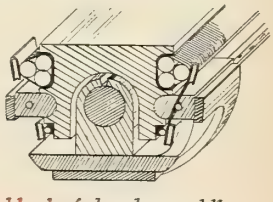
All standard models are guaranteed to operate continuously at 350° F; special models at 400° F and up to 500° F. intermittent. Linear motions can be measured with an output signal level of more than 100 v/″ and resolution to less than 0.001″.



Micro spot weld tap connections (guaranteed single turn connections).



Bonded construction of the resistance element to frame gives new ruggedness.

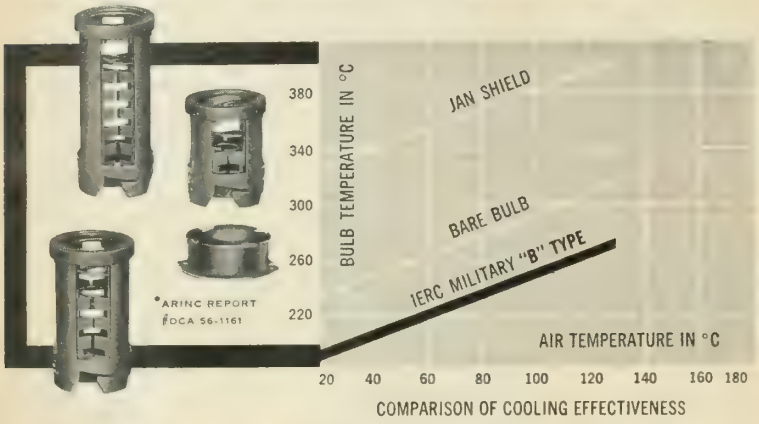


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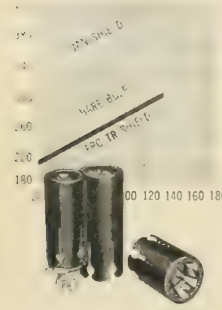


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letters

respect to time. However, such changes were supposed to occur only during cosmic times. P. M. Dirac discarded his theory in later publications, thinking it too extreme. P. Jordan (15) and many other cosmologists used this concept of a variable "constant" of gravitation, but only for purely theoretical considerations and theories. Therefore this concept is out of the question for short-time measurements of G and g.

Finally, such a gravity anomaly as is claimed to occur on Lintz Basalt would be a contradiction to the observed, measured and so empirically proven identity between gravitational and inertial mass. This identity represents the fundamental concept of the general theory of relativity or the Einsteinian theory of gravitation and expressed in his principle of equivalence. A. Einstein explained this principle in a more condensed and simpler form: gravitational and inertial interactions are determined by the same characteristic of matter, that is mass.

It would be difficult to deduce and describe why this same factor mass should behave in a different manner with respect to gravitational and angular or linear accelerations.

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(5) Ch. F. Brush: Proc. Am. Phil. Soc. 60 (1921), 43/61 (1922), 167/83; 62 (1923), 75/89, Phys. Rev. 18 (1921), 125/6
(6) H. H. Potter & P. Philipps: Proc. Roy. Soc. Ldn. 19, (1922) 187/8; Phys. Rev. 19 (1922).
(7) Wilson-Briggs-Owen: Phys. Rev. 20, (1922) 75/7
(8) A. Berroth: Astron. Nachr. 218, (1923) 431
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(10) P. Zeeman: Anz. Akad. Wiss. Wien 26, (1918) 451/62
(11) N. Landolt: Sitz. Ber. Akad. Berlin, 1908, 354/87
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(14) P. M. Dirac: Proc. Roy. Soc. Ldn. (a), 165 (1938) 199
(15) P. Jordan: Schwerkraft and Weltall, 2nd ed. 1955.

W. J. Lohninger
Weston Electrical Instruments Corp.
Newark, N. J.

Missile Literature

To the Editor:

I am intensely interested in the field of missiles and rockets.

Would it be possible for you to supply me with a list of books along with publishers and any other literature that is available pertinent to the subject.

Charles Gurney, Jr.
101 Grant Court
Olean, N. Y.

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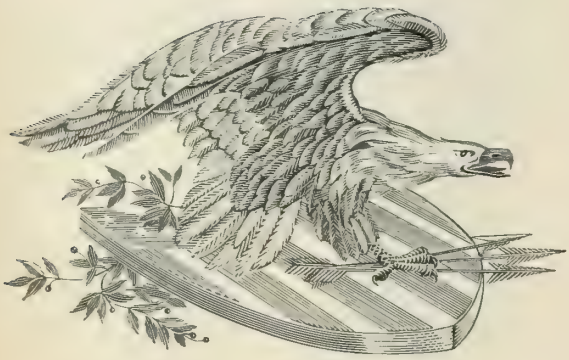
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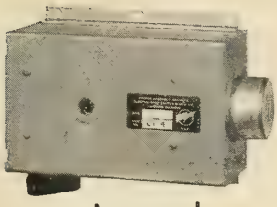
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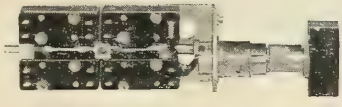


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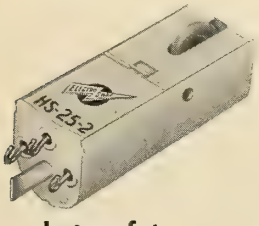
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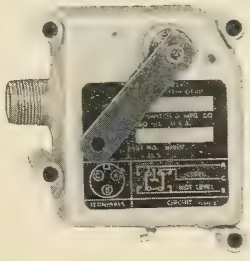
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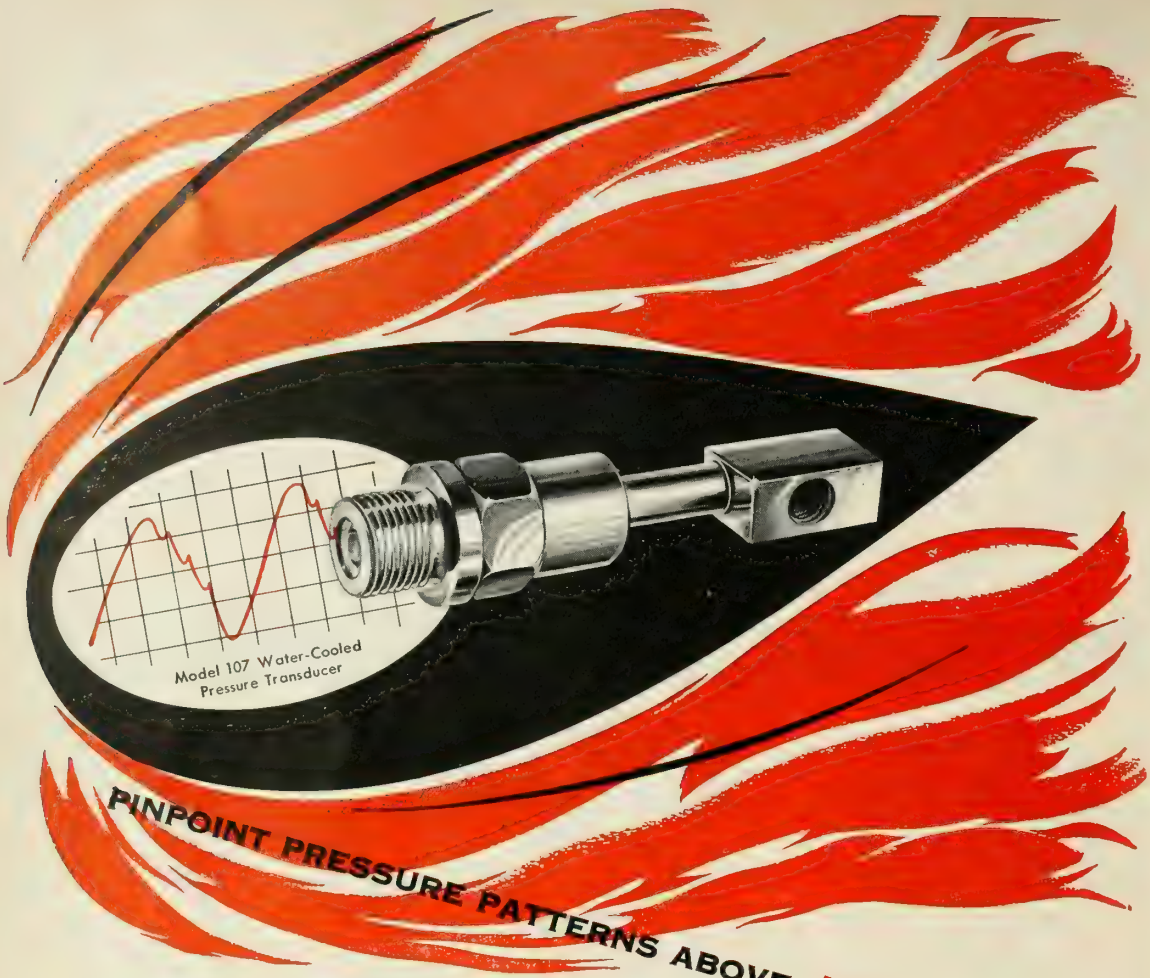


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book reviews

Realities of Space Travel. *Edited by L. J. Carter, ACIS, (Putnam & Co. Ltd., 42 Great Russell St., London, W.C. 1, Price: £1.15.0 ($4.90) plus postage.)*

A fully illustrated 430-page book consisting of twenty-four authoritative articles by sixteen recognized experts on different aspects of space flight including: "The Satellite Vehicle," "Interplanetary Flight," "Physical Factors in Space Flight," "Biological Aspects of Space Flight." Each chapter was originally a paper presented to the British Interplanetary Society.

Among the contributors, Col. P. A. Campbell, USAF doctor, who covers the aeromedical and biological aspects of flight above the atmosphere; L. J. Carter, secretary and journal editor of the BIS, writes about the US Naval Ordnance Test Station at Inyokern and about Woomera; A. V. Cleaver covers rocketry aspects up to a program for achieving interplanetary flight in 33 pages.

L. R. Shepherd, reactor physicist from the UK Harwell Atomic Energy base contributes on the nuclear rocket, cosmic ray hazards and a forward-looking piece on interstellar flight, as well as a clear statement of the basic principles of astronautics; N. J. Bowman of Standard Oil gives his views on food and atmosphere control problems in space vessels.

Professor S. Fred Singer of Maryland University discusses the present practical minimum orbital instrumented satellite. That familiar UK spacewriter Kenneth Gatland in collaboration with A. M. Kunesch and A. E. Dixon, covers the minimum satellite vehicle, while, T. Nonweiler, aerodynamics lecturer at Cranfield College of Aeronautics writes about aerodynamic braking during the descent from orbit.

The book contains useful historical and useful reference curves. It is not for the advanced specialist, but it gives a sound statement of present knowledge in terms that the technician in any trade can understand—the nontechnical can learn almost as much simply by skipping the sums.

The Sun. *By Giorgio Abetti, translated by J. B. Sedgwick, 336 pp. 147 illustrations, 97 figures. $12.00. Macmillan Co., New York.*

Professor Abetti needs no introduction to professional and amateur astronomers. An earlier version of "The Sun" was the recognized text on the subject since its appearance in 1934. A revised and enlarged edition appeared in 1951. This edition was further expanded in 1954 and now makes its first appearance in English as translated by J. B. Sedgwick.

This book evolves from techical data and theories commensurate with interests of the professional astronomer, but is presented in a form intelligible to the layman. Methods of observation of the sun are explained by presenting, with figures and photographic illustrations, the evolution of modern instruments. Spectroscopes, spectrographs, spectroheliographs, spectrohelioscopes, and auxiliary instruments become familiar and meaningful.

The familiar sun spots appear in a new light. Their origin, life cycle, vicissitudes and effects are clarified. Sun spots are generally known for their adverse effect on wireless communication. Apparently they are insignificant in determining the sun's rotation period and its physical behavior.

Perhaps one of the most interesting subjects is the physical constitution of the sun. A chapter of the book is devoted to this subject. In suport of the concept of the sun's physical make-up, the Corona, Chromosphere, Reversing layer, and the Solar Interior theories and interpretations of various phenomena are presented in brief, straightforward fashion supported by numerous figures and illustrations.

The reader will appreciate the extensive studies of the sun. The value of these studies become obvious. The importance of data currently obtained with the aid of rockets will be apparent and the magnitude of knowledge obtainable from satellites is made clear.

Professor Abetti in this book has presented such a comprehensive treatment of this complex subject that not only will it hold the layman's interest, but it will also provoke thought and study by those in technical and scientific fields.

Galactic Nebulae and Interstellar Matter. *By Jean Dufay, translated by A. J. Pomerans, Philosophical Library, New York. $15.00.*

The author, who is director of the Lyon and Haute-Provence Observatories, has succeeded in presenting a most interesting and a thoroughly authoritative book on the study of the diffuse matter in the galaxies. The book provides one of the most complete accounts available of the many diverse phenomena involved in the study of interstellar matter. The book has vocational merit, since it is written for professional astronomers as well as those generally interested in the subject matter.

In part I the types of spectra produced by the atoms and molecules in space are classified and explained. There is also an account of radio emissions from parts of the Milky Way. Part II is devoted to the solid particles of space and the dark nebulae, while Part III explains modern ideas of the physical conditions prevailing in interstellar space and includes a theory of stellar dynamics. In Part IV the behavior of diffuse matter is examined, and the problem of intergalactic absorption is discussed.

In addition to the many illustrations the book is beautifully indexed. It carries a substantial bibliography.

Thinking By Machine. *By Pierre de Latil. Houghton Mifflin, Boston* $5.50

The words automation, electronic brain and cybernetics are now part of our common vocabulary but few people have realized the full implications of the last ten years' progress in the development of self-governing machines. This book describes the principles that make these complex machines possible, as well as the fundamentals of their construction. The book is of great value to electronics and guidance engineers.

This is also a book for those in other fields. Research workers in biology, neurology and other such specialties will appreciate the philosophies and precepts introduced by the author.

Most of all, perhaps, industrial managers will benefit from careful study

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of the theories presented. Many professional engineers may find this a provocative book. They may not always agree with the author but they will probably agree the book is a fine contribution to the sparse literature on cybernetics.

Man into Space. *By Hermann Oberth, 226 pp. $4.50, Harper & Brothers, New York.*

For those who have made their reservations for the first lunar flight, Professor Oberth gives details on what the well-dressed space man will wear. Also covered in this spacecraft guide are satellite rockets, space stations, his famous space mirror, electric space ships and a vehicle for use in getting around on the moon.

Oberth, the father of space flight, dates his interest in astronautics back to 1922 when he wrote his thesis on the subject. Later he published a German best seller "By Rocket to Interplanetary Space." He started work on a research project involving design of the V-2 in 1938 at the Technical Institute in Vienna and later moved on to the rocket laboratories at Peenemunde under von Braun.

In his book, Oberth describes space ships which will run on electricity derived from the Sun, asteroid observatories and special problems which can be expected on a trip through space.

In addition to a detailed description of a moon car, Oberth also includes instructions on how to drive: "The more experience the driver has had on the Earth, the more difficult he will find it to get used to the novel conditions on the Moon . . . On no account should the car just forge ahead and jump at random . . . a stop will be made first, and then a few vertical jumps to reconnoiter the position."

The chapter on space fashions is complete with diagrams. One robot-looking design includes: Front and side windows, containers for compressed air, oxygen and "fuel for the reaction pistol," glove and claw, gripping magnets, short-wave aerial, rear view mirror, hooks and bolts for hanging up suit, heat dissipator, jack for telephone lead, breastplate hinges.

Oberth comments: "The fascinating film star would have his charm very considerably reduced if he wore one of them under actual space conditions."

The why of this book is explained in Wilhelm Meyer-Cords' introduction: "We are on the eve of events to which more fantastic imaginings have been applied than to the majority of progressive mankind's plans and ideas . . . mothers will have every right to know what their sons can expect in their flights through space and wives to be told what dangers their husbands will encounter on their space journeys."

One interesting proposal described by Oberth is a space mirror 27,000 square miles wide which could result in "whole space fleets wiped out," through concentrating the heat of the sun on them. Peacetime projects on which the mirror could concentrate include lighting up entire towns at night, melting icebergs, influencing climate and weather, including the control of cyclones.

Oberth estimates the cost of a space mirror at $3 billion—"less than the cost of a small war." He suggests, however, that this project be held up until his electric space ship is ready to go into service so that material for the mirror could be brought in from asteroids or the moon as "this would be cheaper."

The professor believes that many of his ideas will be put to use by 2000.

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Titan Now Our Number One Missile

More Advanced Than *Atlas*
Titan Testing Is Underway

By Erik Bergaust

DENVER—High Air Force officials have revealed to m/r that the TITAN Intercontinental Ballistic Missile effort is in a far more advanced stage than was expected less than a year ago, and that the Martin super missile actually will be a "better" weapon than the ATLAS. Furthermore, Defense Secretary Charles E. Wilson recently referred to "another" intercontinental missile as being more promising than the ATLAS. Obviously, he was referring to the TITAN. It has also been revealed that the TITAN will be more advanced designwise, and that the component test program for this second ICBM is well underway. Aerojet's president Dan Kimball has confirmed that his company is well ahead in development of the 300,000 pound thrust first-stage and 60,000 pound thrust second-stage engines.

A visit to Martin's enormous facility here reveals that the company has exceeded all expectations in getting the *Titan* program underway. Four engine test stands are almost completed, airframe manufacturing is in full swing.

Sure, Martin officials can't even talk about their missile, but it has been known for some time that the *Titan* nose cone project is as far advanced as that of the *Atlas*.

The initial USAF *Titan* development contract, totaling $358 million, has reshaped the geographic organization of the Martin Co. The *Titan* program, centered in the new $10 million facility here, is already in its manufacturing stage.

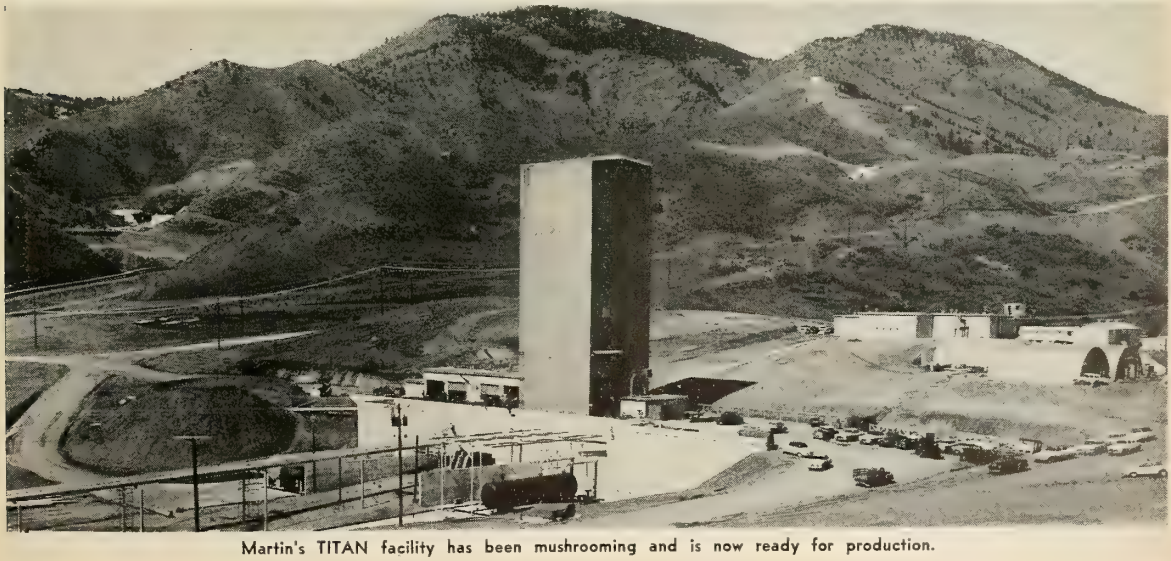
As a result, a $2 million plant expansion is in the mill. Present employment of 2,500 is expected to reach 5,000 next year. Company officials say building of a landing strip is planned to expedite delivery of parts and for transporting military and civilian people to the site.

In *Titan* guidance, American Bosch Arma Corp. of Garden City, N. Y., is spearheading inertial guidance development and Bell Telephone Laboratories/Western Electric Co. at Whippany, N.J. is working on radio guidance.

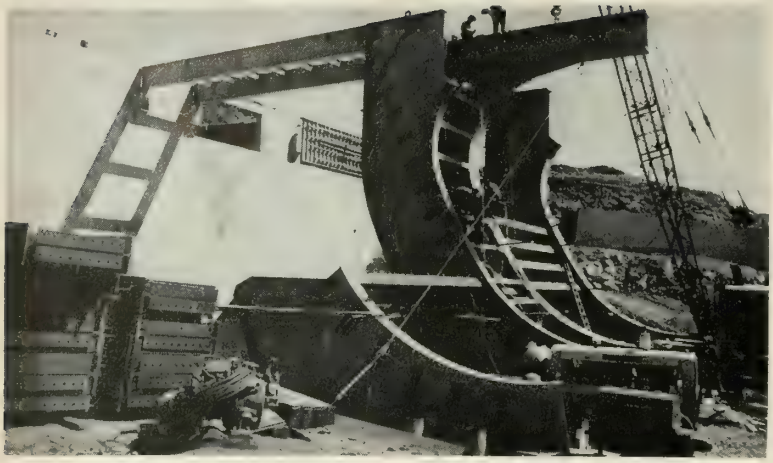
Titan is a two-stage weapon with the sustainer rocket mounted directly over the booster. General indications are that the length of the missile mounted and ready to fire is approximately 100 feet with the diameter of the booster maybe 10 feet; that of the warhead and final stage, 6-to-8 feet. Fueled weight is undoubtedly well over 100,000 pounds.

The *Titan* program now is broken down into eight departmentalized functions which perform specialized responsibilities in successfully completing the project. Several of these are well underway.

The propulsion section, which has the responsibility for the engine installation, its propellant feed system and its satisfactory marriage to the airframe, is working closely with Aerojet, planning first engine tests at the



Martin's TITAN facility has been mushrooming and is now ready for production.



Soon to be completed, this test stand at th Denver plant of Martin will be used for early static testing of the TITAN.

Denver site.

The airframe section has the responsibility for the design of the structure, the orientation of the various systems within the structure and the general configuration of the missile. This work is in the mill.

tegration of guidance within the entire system. Little is known of guidance progress, but it must be assumed that it is as advanced as the *Atlas* guidance.

The ground support and equipment section, which has the responsibility of supplying all of the neces-



A total of four static test stands are being built—all expected to be operational this year.

The guidance and control section has the responsibility for the analysis, design, development and installation of all of the control equipment which will help the vehicle maintain a stable flight attitude at all times and the in-

sary equipment required to launch the vehicle, is well ahead in its overall planning. In all, the *Titan* program is well advanced, and, needless to say, Air Force officials are pleased with the progress.



This is a 28,000-gallon, stainless steel "thermos bottle" type tank which will be used for liquid oxygen and other fuels. The tank is 11 feet 6 inches in diameter, and 75 feet in length.

Army Successfully Fires *Jupiter* 1,500 Miles

After two failures earlier this year, the Army recently succeeded in firing a *Jupiter* mid-range ballistic missile to the limit of its designed range, or approximately 1,500 miles. The instrumented vehicle attained an altitude of approximately 250 to 300 miles.

The *Jupiter* carried instrumentation in place of the warhead it would normally carry in operational use. It was controlled by a pre-programmed auto-pilot which held its attitude during flight to the programmed course. Later vehicles will be equipped with a full-fledged guidance system which will include computing as well as sensing elements.

Reds Propose Freight Rockets

Russia's official Defense Ministry newspaper *Red Star* has predicted that "in the near future" missiles may be used to transport troops and supplies.

"It should be noted," said the Soviet military organ, "that plans for using ballistic rocket missiles to move troops and materiel are actually not as far from reality as it might seem at first glance. Delivery of ammunition and certain kinds of arms can already be accomplished by some types of suitably-modified military rockets. . . .

"The question arises, what would be the cost of delivering supplies to troops by means of guided missiles? Undoubtedly such a supply system would not be cheap. However, the advantages which this method present justify the cost. Besides high speed and reliability in delivering materiel, use of guided missiles can significantly lower the cost of supplying troops by ordinary methods. These missiles would reduce the amount of rear echelon transport facilities. . . .

W. R. Grace Produces Purified Thorium

W. R. Grace & Co. will build a plant at Erwin, Tenn., to produce purified uranium, thorium, and rare earth alloys and metals.

Thorium is expected to find extensive use in magnesium alloys for jet aircraft and missiles. First production is tentatively planned for late this year.

Propellant Payoff Found in Systems Contracts

FRENCH LICK, Ind.—The missile and rocket industry gulps down huge quantities of chemicals and looks with hungry eyes toward compounds not yet synthesized.

Just what these chemicals are and what quantities are involved is a puzzler for most chemical people. An attempt was made to supply answers at a seminar here on May 13 and 14.

The program was put on by the Commercial Chemical Development Assn. in cooperation with the Assistant Secretary of Defense (Research and Engineering). Some 180 chemical people—product developers, market analysts, plant managers, and door-beating salesmen—assembled to hear the theme: "What the Rocket and Missile Program Means to the Chemical Industry." Panelists gave a run-down on various phases of liquid and solid rocket propellants and new exotic fuels.

J. J. O'Connell, Program Chairman stated that the chemical industry would like to know what chemicals will be needed for the next ten years. Emphasis was placed on propulsion. Although attendees generally were left with the impression that the chemical market for missiles is big, it was agreed the exact status is difficult if not impossible to evaluate.

Big factors in this nebulous situation are military security, trade-secret tendencies, and systems engineering. Industry spy systems have been able to cope with their competitors' trade-secrets but security and more important, systems planning have floored many a qualified chemical firm attempting to sell products in the missile field. The answer: get in on the ground floor when a system is planned.

Systems the Key

To really cash in, then, the chemical industry will have to adopt the systems attitude. This concept was advanced early in the program in a paper given by Stewart A. Johnston of Ramo-Wooldridge Corp. In addition to the usual propellant logistics criteria, two of the biggest propellant criteria are the need for high density and high specific impulse. The optimum, according to R-W, would be to manufacture all propellants right on base. Presumably this idea will be utilized in building LOX plants right on an ICBM base.

An idea of how much new chemicals might be utilized in a new propulsion evaluation program was given by Dr. John F. Gall of Pennsalt Chemicals Corp. Property testing requires but a few pounds of materials but advances to several hundred pounds while still in the laboratory stage. Static engine tests of a few thousand pounds of thrust might require 400 pounds of propellant per second with a total consumption of 2-4 tons. Thus, consumption in a more advanced test phase would soar to several hundred tons per month.

After this, during peace time conditions, the use might sag considerably. Requirements would only be for replacement, training, and minor development programs. And unless, other uses could be found this would represent a bad product growth curve which might seriously deter the chemical firm from starting in the first place. Dr. Gall, in making his pitch for fluorine propellants, stated that present production is equal to 10,000 tons per month of elemental fluorine and that even a large program would not tax the available fluorine capacity.

Managing Molecules

In an unusually detailed analysis, Rocketdyne's Research Chief, John F. Tormey stated that F-O-N-C-H chemical systems would form the basis of liquid propellants for at least ten years and that during this span we might expect specific impulse to be jacked up by about 50% over present systems.

Future oxidant systems will take advantage of more fluorine and will have increased stability and increased boiling points. Mr. Tormey was confident that materials progress would keep up with the hotter combinations. Though lithium, boron, or beryllium might play greater roles in propellants, Tormey was not so optimistic about aluminum or magnesium compounds.

The storage life of the *Nike I* is now five to ten years even though the system is obsolete. Richard B. Canright, of Douglas Aircraft stated that the booster was a multi-perforated double base solid developed by Allegany Ballistics Laboratory. The sustainer uses UDMH/JP-4 (dubbed M-3 fuel) and IRFNA. Temperature storage limits are now —50°F to 140°F.

A great deal of interest was generated when E. A. Weilmuenster of Olin Mathieson presented his run-down on Project Zip. Based on early German and British work, OM embarked on its boron program in 1952 for BuAer. Of particular interest were the boron hydrides which gave combustion heats of 28,000-32,000 BTU/lb.

Declining to say just what compounds were now being manufactured, it was stated that there was "lots of interest" in the liquid pentaborane. The high energy fuels are not spontaneously ignited in air, and have flame speeds comparable to JP-4. HEF systems are in the works for several missile and aircraft systems. With development, HEF might be used in the B-58 system. OM also thinks that there are commercial applications for Zip.

The liquid portion of the program was terminated by Robertson Younquist who described engine developer's applications and needs from his Reaction Motors viewpoint.

Solids Growing

With some 1-5% of a production missile's cost, the propellant is but a small item said H. W. Ritchey of Thiokol. However, using the Thiokol-made polysulfides in solid propellants has paid off for the firm since some 50-75% of income is from rockets. Thus small chemical firms such as Thiokol, imbued with the systems concept, can profit from a low-volume, high-cost item.

No Upper Size Limit

Lyman G. Bonner emphasized that solid propellants are the most mature of rocket systems and that Allegany Ballistics Laboratory operated by the Hercules Powder Co. was called on early to supply double-base propellants. World War I techniques were the only ones available at the start of World War II. However, double-base solids can now be cast and performance is edging up toward the limit of about 250 Isp. Bonner said that the upper limit of grain size has not yet been reached.

According to Rohm & Haas Co.'s Redstone Research Div. General Manager, Allen R. Deschere, development of solid propellants differs from other chemical products mainly in the rather dangerous nature of the materials being handled. R&H is content with operating a research lab at Redstone and has no plans for getting into the missile business.

How to Get In

Although the amount of chemicals used in missiles may not be huge, it could be significant for newer materials and for smaller firms. The big payoff is seen to be for those who get in on a systems basis. The road for the chemical industry is clear: get cleared, get out and find out what is needed and start to make it.

Missiles Highlight Paris Air Show

U.S., Britain and France Show the Most Security Keeps Best from View

By Anthony Vandyk and Jean-Marie Riche



PARIS—U.S., British and French missiles were prominently featured at the International Air Show here. Ranging from the Northrop *Snark* and Martin *Matador* to the smallest experimental rockets, the missiles were the main talking point of visitors. It was clear the European aircraft industry has suddenly become missile-minded.

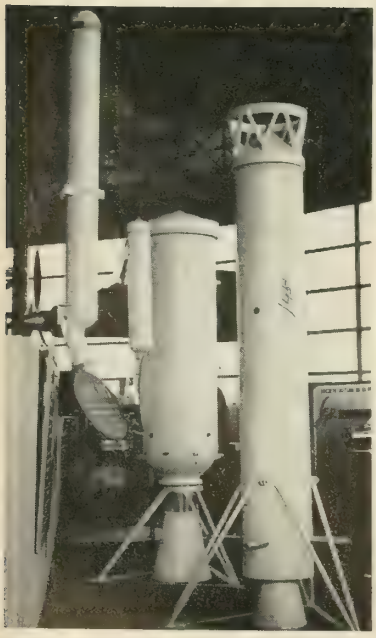
No major manufacturer represented at the show was without some sort of missile exhibit or project. Nonetheless, security prevented any of the latest European missiles from being shown but there were plenty of older models on the British and French stands. Most of them appeared to be subsonic or transonic.

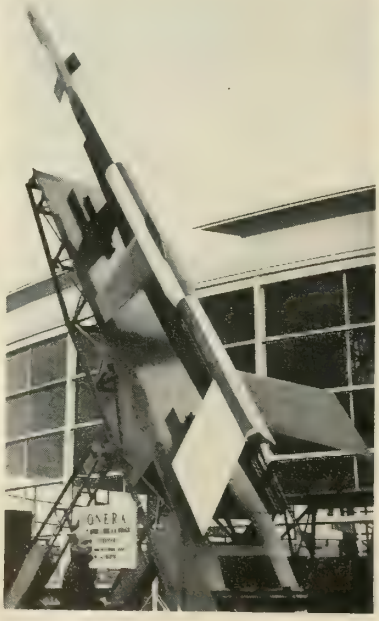
The Bristol *Bobbin* test vehicle made its first public appearance at the show. The Australian *Jindivik* was shown by Fairey Aviation together with its *Fireflash*.

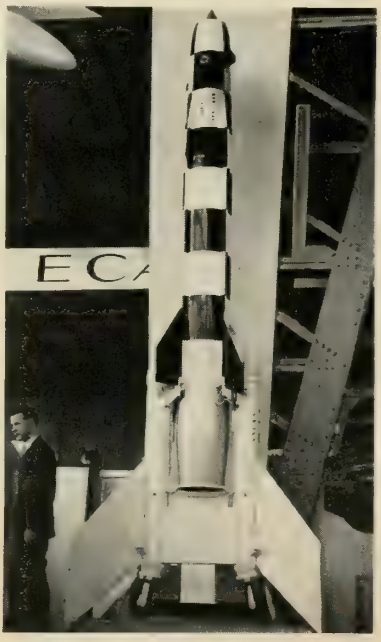
The de Havilland and English Electric/Napier stands held many missile exhibits.

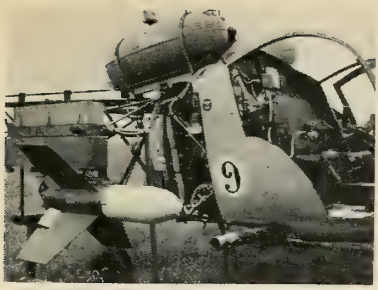
The French, like the British, mainly showed test vehicles. SNCA du

Demonstrating that the French have not exactly been lacking in missile development, this array gives some idea of the different lines of approach being taken by the French aircraft industry. To the left is the Matra 510 air-to-air missile. At the lower left is a selection of solid propellant rocket engines manufactured by S.E.P.R. (Societe d'Etude de las Propulsion Par Reaction). Below center, an experimental two stage test vehicle built by ONERA. Below right is the experimental ST 450 missile (SNCA du Nord) for ramjet testing. A ground-to-air missile has been developed from this vehicle. SNCA du Nord is also working on a ramjet.













This series of pictures shows the French anti-tank missile SS 10, from which the U.S. Army DART was derived. Simplicity and versitility is a feature of the French missile. Both the SS 10 and SS 11 (not shown) are wire guided. Speed of the SS 10 is 328 feet per second; of the SS 11, 655/820 feet per second. Ranges are 1.25 and 1.85 miles respectively. The SS 11 is stabilized in flight by a jet deviator.



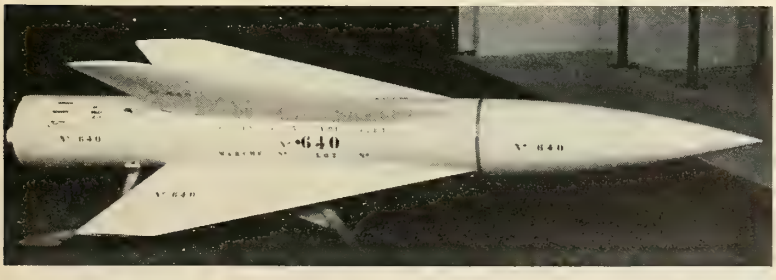
Nord was permitted to display its CT-10 and CT-20 drones and to present full data on them which will be reproduced in a future issue of m/r. Nord's SS10's highly successful SSMs were also displayed. Matra's production AAM was slung under a Dassault *Mirage* interceptor.

During the show it was disclosed that France's Bronzavia has licensed its missile ram-air turbine to General Electric for U.S. production. SEPR showed a large number of rocket motors including the model 734 which develops 57,700 lbs. of thrust for four seconds. SNCA du Nord showed evidence of important work on ramjets.

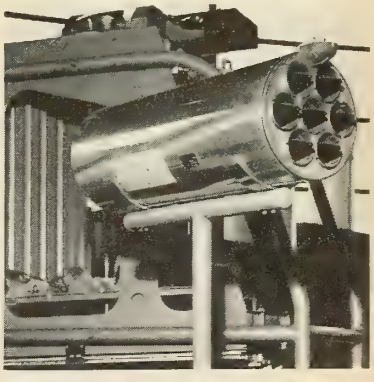
A significant presentation was made by SNECMA of its *"Flying Atar"* VTOL—a piloted jet engine with no wings or other control surfaces. The controllability of this device appeared to be excellent.

It was difficult to obtain specific information on what new missiles are being developed by the French industry. It is known, however, that the French government wants a French atomic ICBM to be ready by 1965 at the latest and for effective SAMs to be in service much earlier.

Improved AAMs are already on the way. In fact, all indications are that the French missile industry is making excellent progress.







To the upper left is the Nord 5.103 air-to-air missile now in production for use on super-MYSTERE day fighters and VAUTOUR all-weather fighters. Carrying a warhead of 57 pounds of TNT the missile has a range of 6.2 miles and a speed of 1640 feet per second. It's either a beam rider or radio guided. Lower left is the CT 20 target drone which have been used by French forces and exported to Britain and Sweden. Above is a MATRA rocket launcher.

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New Propellants Insensitive To Shock

A new solid propellant, a replacement for black powder and diglycol propellants, was described by Dr. G. von Francois, formerly a special Speer Ministry employee. No. 36E, dubbed yellow powder, consists of 53.5% tetranitro carbazole, 42.5% potassium nitrate as oxidant, 2% carbon, 3% wood flour and 4% polyvinyl acetate as binder. The cool-burning propellant can be used over a temperature range of —58° F to 140° F. Not sensitive to shock, the plasticized mixture burns to give a slightly yellow smoke exhaust.

German solid propellants formerly based on black powder or diglycol dinitrate now appear to be shifting to the high energy composites. Also, the production of synthetic glycerine by one of the Farben groups will now give capacity for production of nitroglycerine-type double base solids. Another propellant combination is based on tetranitro diphenyl amino sulfone. Several German labs are doing research on new organic solid monopropellants: nitro, nitrate, or nitroso compounds.

French SEPR Builds Two Big Boosters

The French SEPR group has successfully scaled up solid propellant rockets and have come up with two new boosters:

	SEPR 73	SEPR 5052
Thrust, lb	55,000	29,700
Burning Time, sec	4	4
Chamber Pressure, psi	1,030	1,030
Propellant Weight, lb	940	620
Total Weight, lb	1,625	1,030
Total Length, in	106	105
Diameter, in	25	18

Propellant type is not known.

Longer Satellite Lifetimes Predicted

At the recent American Astronomical Society meeting in Cambridge, Theodore E. Sterne postulated that the *Vanguard* orbit may result in a satellite decay period of 8-10 years based upon latest Air Force Cambridge Research Center atmospheric model. If this turns out to be so, subsequent satellites will be launched at lower altitudes or lower speeds to obtain upper atmosphere density checks within a shorter interval.



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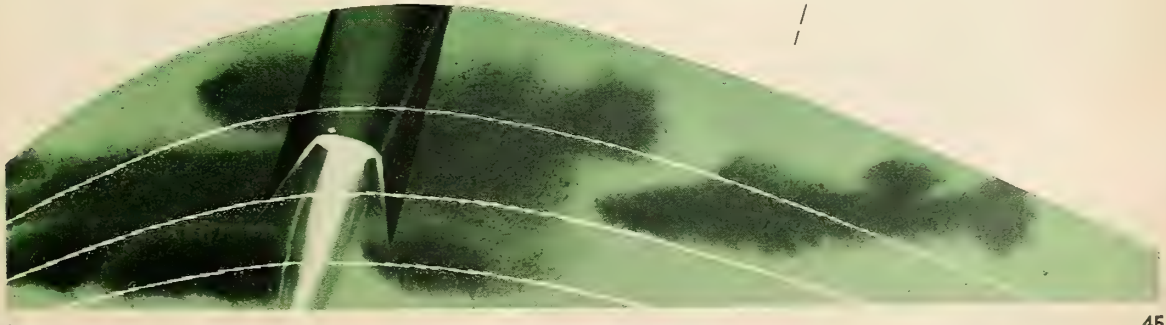
FLAMEMASTIC protects against high-velocity combustion heats, ranging from 3000°F. upward. This insulation provides positive protection for vital electronic equipment.

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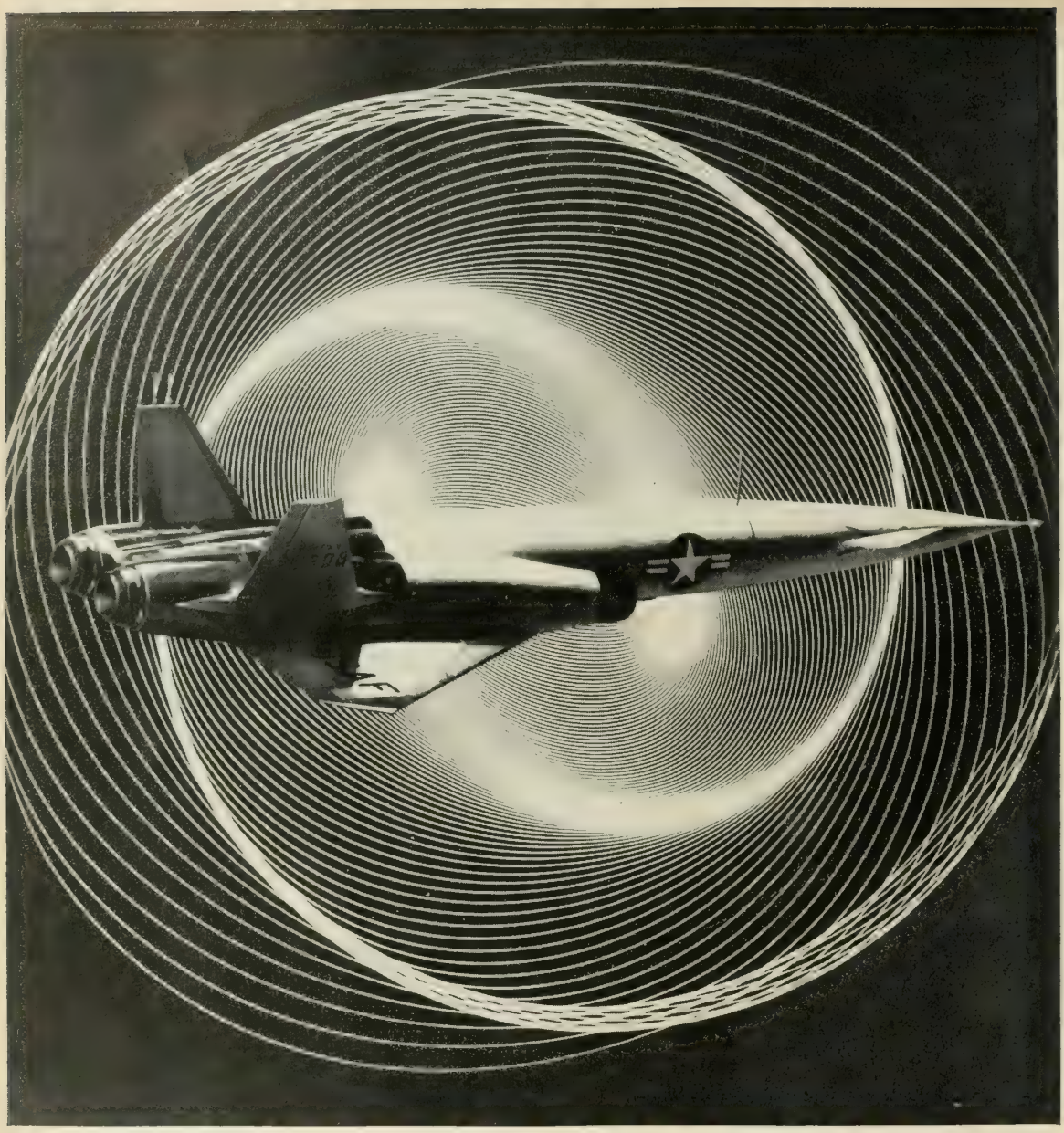
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Missile Program Sharply Criticised by Congress

The House Appropriations Committee subtracted $2,586,775,000 from the military appropriation request for the fiscal year beginning July 1, but insisted the cut will not jeopardize U.S. military striking power.

The lawmakers reported out a bill recommending $33,541,225,000 in new obligational authority for the Defense Department in fiscal 1958, compared with the $36,128,000,000 originally requested by the Administration and the $34,698,523,000 actually voted for the current year.

In support of its cut, the Committee said that the Soviet military threat to the U.S. and its allies appears to have "somewhat abated," but it acknowledged that the Soviet Union is closing the gap in military power.

"In the field of missiles we are in a nip and tuck race with Russia. We are no doubt ahead of the Soviets in the field of guided missiles generally. In the ballistic field, we are probably behind the Soviet Union in progress made in the perfection of the Intermediate Range Ballistic Missile. In the Intercontinental Ballistic Missile area, we are very probably ahead of the Soviets," the Committee said.

The House group had some harsh words in its report for what it called the "apparent lack of timely, effective and decisive action on the part of the Office of the Secretary of Defense in achieving a well-rounded, coordinated guided missile program at minimum cost commensurate with an adequate system." (See Industry Spotlight, p. 169). The Committee strongly urged more prompt and effective evaluation of competing military missile projects, particularly for the non-ballistic missile area.

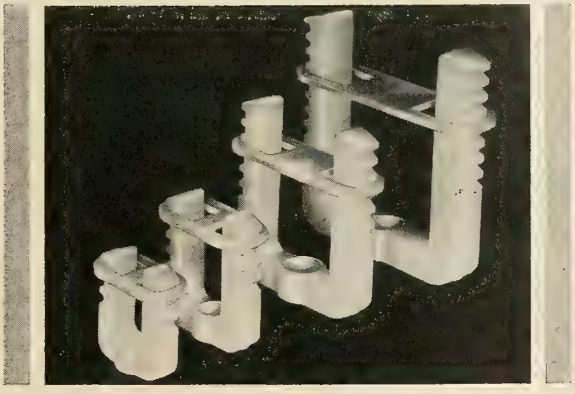
The congressmen agreed that a certain amount of duplication is necessary in the ballistic missile projects, but added: "It is hoped that within the next few months the ballistic missile program will become clarified and the maximum of lost motion eliminated."

Except in the case of the Air Force, the precise impact of the Committee's action on the missile program was not disclosed. The USAF's $1,414,800,000 request for missile procurement ($676,900,000 for ballistics and $737,900,000 for non-ballistics) was trimmed $70,000,000 "as a reflection of the Committee's dissatisfaction with Air Force efforts in this area," but it was stated that none of the reduction is to be applied to the ballistic projects. Another $5,000,000 was lopped from the Air Force's $105,700,000 request for missile spares to take account of the cut in missile procurement money.

The Committee also gave the airmen a tip on cetrain missiles they might do well to abandon. It said some of the 18 separate missile development and production projects now carried on by the Air Force are of "doubtful value" and it included the Bell *Rascal* air-to-surface missile in this category, noting that the Defense Department feels it is a "marginal" weapon.

A $12,000,000 cut was recommended in the USAF request for $661,000,000 in new research and development funds, but this was not allocated among specific projects. The Committee said this reduction was ordered to emphasize that all possible economies should be effected, particularly in scientific and engineering manpower.

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ment request for hardware, including missiles, was reduced by $516,000,000—the amount of the total request the soldiers expect to carry over into fiscal 1959 unobligated. The Committee acknowledged that the reduced amount will give the Army less latitude than it wants, but said the amount should prove adequate if improvements continue in management and planning operations. A cut of $8,000,000 was also ordered in the Army's $400,000,000 R&D request.

The Navy buys missiles in two separate accounts—aircraft and related procurement administered by the Bureau of Aeronautics and ordnance and ammunition, handled by the Bureau of Ordnance. BuAer's request for aircraft, missiles, drones and related items was cut $120,000,000 to $1,812,000,000, but the Committee expressed confidence that the Navy can carry its program with the lesser amount since experience has shown that considerable savings through program changes, contract repricing and the like may be expected.

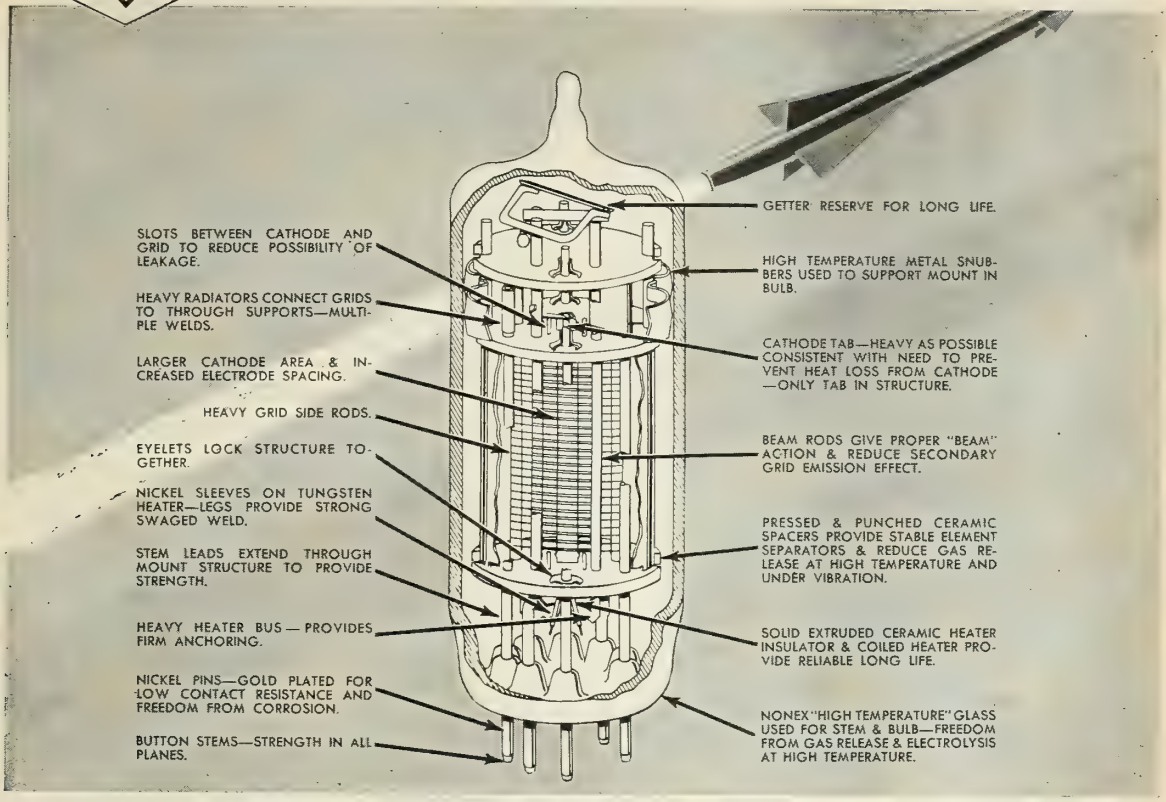
BuOrd's $256,000,000 request for ammunition and missile money (including *Polaris*) was reduced to $176,000,000, on the strength of BuOrd's past poor performance in hitting its obligation targets, anticipated reimbursements from the military assistance program and the volume of carry-over funds available. The Navy's total R&D request of $505,000,000 was also cut by $10,000,000.

Soviet Research Poorly Organized

Professor Peter L. Kapitsa, the celebrated Soviet physicist, in an article published in the Moscow *Pravda* last month complained of the poor organization of certain important research projects in the Soviet Union today. Giving the construction of an atomic-powered airplane as an example, Doctor Kapitsa pointed out that one Soviet scientific agency usually takes over the entire project, then farms out certain parts of it to various other agencies, whereas a better approach would be for only one team to be responsible, without farming out even the project's smallest parts.

He listed agencies and specialists in atomic energy, thermotechnical problems, and aerodynamics among those now involved in the building of the Soviet atom-powered plane. He hinted in his article that some of these agencies and experts do not work with others in entire harmony. Better team work, through greater centralization, is necessary, declared Dr. Kapitsa.

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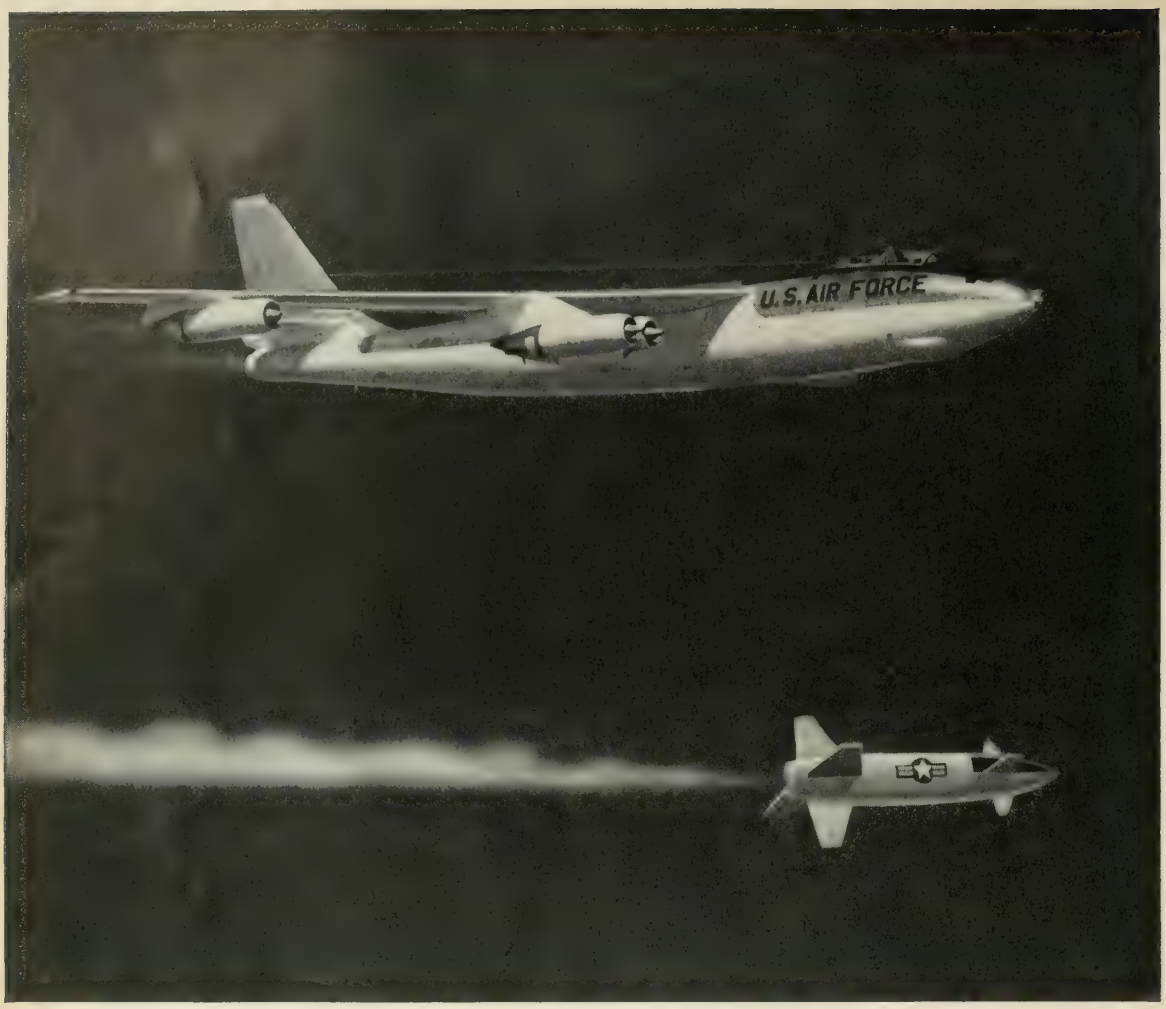
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6094	—	6AQ5-6005	6.3	0.6	T-6½	TE-18
6853	6106 5Y3	5Y3	5.0	1.7	T-9	TE-45
6384	6AR6 6098	6AR6	6.3	1.2	T-11	TE-27
6854	6385	2C51 5670	6.3	0.5	T-6½	TE-47
6486A	6486	6AS6	6.3	0.25	T-6½	TE-43
6582A	6582	6AK5	6.3	0.25	T-6½	TE-44
6754	412A	—	6.3	1.0	T-6½	TE-36
6851	5751	—	6.3	0.5	T-6½	TE-42
6877	—	Half of 6080	6.3	0.8	T-6½	TE-48
6900	5687	5687	6.3	0.9	T-6½	TE-54
6889	—	—	6.3	1.2	T-11	TE-52
6082A	6082	6082	26.5	0.6	T-12	TE-55

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The personnel responsible for this successful program has recently been regrouped to form a new *Guided Missiles Division.* Its sole function is to provide complete and coordinated management and production for any weapon systems program.

The men who make up this division ar a skilled and diversified team of specialists with a total of some 100,000 man-years of experience in guided missiles. Prior to "Rascal", they were responsible for Tarzan, Shrike and Meteor. Current responsibilitie also include important components for the Niké, Hustler, Regulus, Navaho and various I. C. B. M. and I. R. B. M. programs.

These men have past success to attest to their capabilities and foretell future accom plishments. They will be heard from again and again for important achievements in the years ahead.

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Russians Report Super Peroxide

A member of the D. I. Mendelev Institute of Chemical Technology in Moscow, A. P. Purmal, suggests the existence of a super hydrogen peroxide—H_2O_4. Reporting in the *USSR Journal of Physics,* the scientist told of irradiating a fresh hydrogen peroxide solution with a mercury arc light to drive off all oxygen. Oxygen evolved is measured and the solution titrated with potassium permanganate.

Titration results were shown to be lower than calculated. The gas evolved gives the bonded oxygen while titration gives the hydrogen combined with peroxide oxygen. The scientist states that the two methods agree when no other peroxide forms are possible. Purmal, in typical scientific fashion, however, wants other confirming proof.

If super peroxide could be prepared, it would be very useful as a replacement for normal peroxide. Although containing some 97% oxygen (hydrogen peroxide has 94%), it could yield twice as much *available* oxygen. Other desirable properties hypothesized: higher density, ease in catalytic decomposition, high boiling point and low freezing point. The next step, perhaps already in the mill, would be isolation and study.

Controversial Clue Sparks Symposium

Over-instrumentation was one of the most controversial subjects discussed at an informal missile forum held during the Instrument Society of America's 3rd National Flight Test Symposium in Los Angeles, Calif.

All participants agreed, however, there was too great a variation in the nature of tests to establish an arbitrary line between too much and too little.

It was emphasized that all firing tests of complete missiles should be made on an "inter system" basis by placing a boundary or engineering parameter around each system and measuring only such actions as take place between systems. This theory assumes that component accuracy is within specified tolerances and that each component of each system has been thoroughly checked prior to the test of each system.

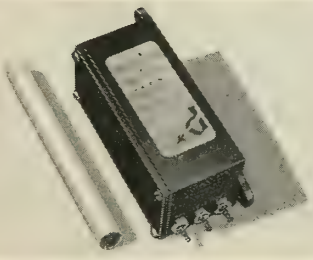
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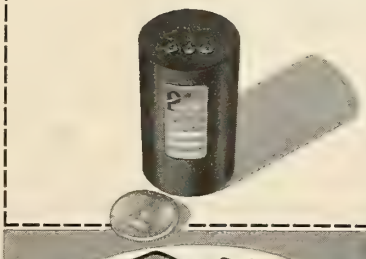




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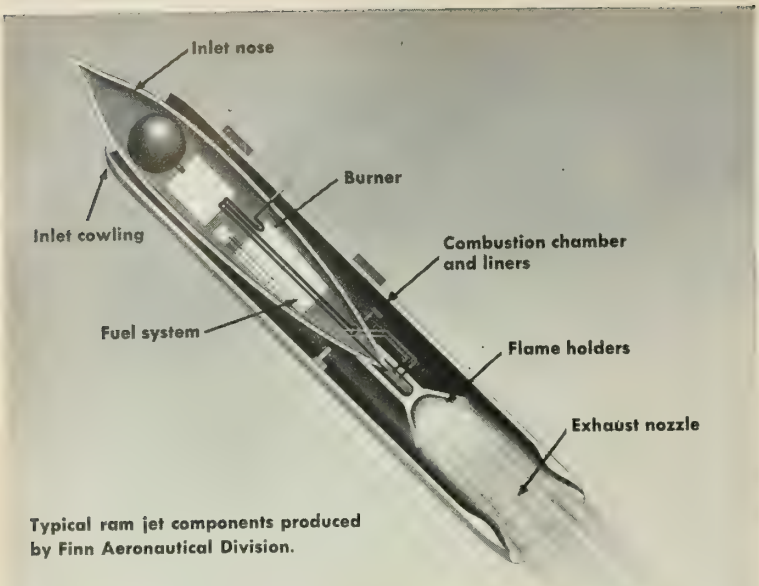
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measured at the tame time system performance is being evaluated. It was felt that component measurement has no place during a test firing other than sufficient instrumentation to "fingerprint" which components *could* have malfunctioned. This technique, it was stated, was one means of providing maximum information with a minimum effort, resulting in fewer dollars spent.

It was stressed, however, that the amount of instrumentation required for test firing varied with the project's size and complexity. Although an aircraft may have hundreds of hours of flight testing prior to acceptance, a missile must render the bulk of its information in a single flight, and missile engineers need all the information they can get on the performance of any system or component involved. Some concern over inadequte instrumentation during test firings was also expressed.

Pointing out that as new equipment and new installations are made, new instrumentation will be required, a representative of one missile test facility noted that their static test instrumentation was increasing at the rate of approximately 20 per cent per year, but the additional instrumentation tended to reduce the number of tests required.

There was general agreement when several of the panel and members of the informal "workshop" declared the responsibility for the amount of instrumentation should be a decision of the instrumentation engineer after an evaluation of the design engineers' requests.

French Astronomer Speaks at Harvard

The well-known French astronomer, Gérard de Voucouleurs, recently told a Cambridge, Mass. audience why he would like to have a close look at the planets. Speaking at a panel discussion at Harvard University, he excluded all the bodies of the solar system but Venus and Mars for reasons of distance or temperature extremes.

Dr. de Voucouleurs would like to determine the mass of Venus by satellite techniques, a quantity inaccurately known today because of the fact that Venus lacks a natural moon. He suggested that radio-ranging could be employed to find not only the depth of the atmosphere but the diameter of the planet. Observations, he said, could be made either by artificial satellites or some sort of probe.

Mars received the lion's share of the French astronomer's attention. Among the studies that could be made,

Dr. de Voucouleurs discussed the following: oblateness and internal structure and discrepancies between present optical and dynamical determinations, fine structure of surface markings, continuous strip mapping surveys, spectroscopic tests of the atmosphere (carried out either between two vehicles or using one with a reflecting mirror), radio observations for determination of Martian relief, variable frequency sounding for detection of ionized atmospheric layers, possible ring-current investigations and magnetometer surveys. He felt that it may be feasible to shoot rockets into the atmosphere from a satellite to determine wind velocities and directions.

Naval Factory Honors Rocketeer

The Naval Powder Factory at Indian Head, will honor the late Dr. Robert H. Goddard on 25 June 1957 by dedicating its new power plant in his name. It will be the Navy's first high pressure (900 lbs.—825°F), centrally controlled, electric and steam generating plant.

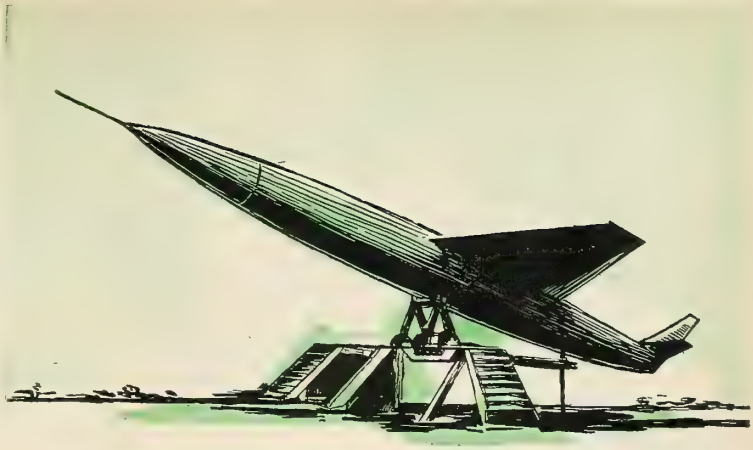
The Naval Powder Factory has supplied the Navy's need for cannon powder since 1900 when the manufacture of smokeless powder was begun.

Today, the powder factory is devoted almost exclusively to the scientific investigation of propellant ingredients, grain design, and experimental production, as well as full scale manufacture, testing, inspection and surveillance of propellants for rockets and guided missiles.

Dr. Goddard conducted rocket research at the powder factory between 1920 and 1922. His efforts were directed toward devising a rocket driven, deck-penetrating bomb.

Tiny Meteorite Detector Developed

Instrumentation for measuring meteoric surface erosion or penetration depth has been developed which weighs only three quarters of an ounce. Developed by Professor S. Fred Singer at the University of Maryland, the device utilizes Sr-90 as the radioactive source in a transistorized circuit. The system is adaptable to operation from either the Minitrack 22 volt supply or, with a different circuit, to 2.5 volts. Current drawn is only 0.1 microamperes. Tests are being run in a shock tube to simulate high speed meteoritic dust particle impacts. The experiment appears suitable for both satellite tests and high altitude sounding rockets.



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Moscow Claims to be Building an Atomic Plane

They are now building an atomic-powered airplane in Moscow, it has been announced by the Soviet government. The plane will make uninterrupted globe-circling flights at speeds up to 1800 mph. It will also fly nonstop from Moscow to Mirny, the new Soviet base in Antarctica.

"We need regular air communications with Mirny and other Antarctic points," Professor G. Pokrovsky, the chief Soviet authority on atomic planes declared recently.

Despite the fact that the Soviet atom plane is as yet in its first preliminary phase of experimentation, Pokrovsky and his associates have not the slightest doubt that the plane will be a working reality soon. Professor Pokrovsky and his staff admit that there are still unsolved problems but they claim Russian science is confidently on its way to their solution.

Another Moscow physicist-mathematician, Y. Balabanov, elaborates: "The most serious handicap in the utilization of nuclear energy in airplanes is the heavy weight of the protective concrete walls safeguarding passengers from harmful radiation of the reactor. This weight reaches 100 tons.

"Should we succeed in reducing the weight of such walls to 40 tons, such an airplane could lift a cargo of 15 tons and could carry 180 passengers at 1600 kilometers per hour."

Professor Pokrovsky admits that "the problem of relaying heat from the reactor to the motor is also complex." Still, he says, the Soviets can and will make it light and compact. He feels that the entire plane could weigh about 100 tons.

The plane's reactor will have to work at temperatures of more than 1000°C. "What materials are capable of bearing this heat without disintegration or even softening?" asks Pokrovsky. "What materials would successfully resist the furious bombardment by neutrons able to cause complex changes in matter?"

But such materials can be found, the Soviet scientist asserts. On the one hand, science must awaken new and yet newer forces of nature to action.

Atomic power will make the future plane's speeds exceed by far even the top rates of present-day supersonic aircraft. The surface of the plane will become so heated that it will generate tremendous streams of super-hot air around itself. Therefore men must have new, heat-resisting alloys for the plane —different alloys perhaps than those for its reactor. Moscow's scientists are now laboring on this problem too, with every prospect of early success, Dr. Pokrovsky tells us.

Pokrovsky adds that future atomic aircraft will have rotating jet motors which, on the plane's ascent, will assume a vertical position and will thus give the plane vertical takeoff capabilities. "Just like a helicopter."

Balabanov adds:

"Such an atom-driven plane will be able to fly endlessly. With a supply of 1000 kilograms of nuclear fuel, an atomic airplane would have operating power at its disposal equal to about 2 million kilograms of benzine."

This means, continued the Moscow spokesman, that interplanetary flights will in due time, become a possibility. "A rocket to be used for this purpose will have to move in airless space," Balabanov reminds us, "and for its jet-propelled motion a sufficient supply of liquefied gas is necessary."



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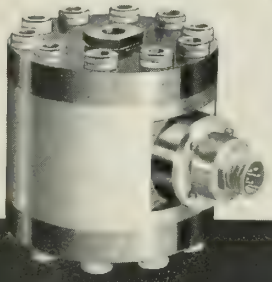
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Rocket Trends



By Erik Bergaust

Missile talk in recent months—for good reasons—has been mostly about intercontinental vehicles. *Navaho* versus *Snark*. *Atlas* versus *Titan*. These missiles will continue to be in the news for years to come because they are important. The long-range missiles have top priority. They should have.

But let us not forget that intercontinental missiles make up only part of the important arsenal that is required for the defense of this country and the rest of the free world. Let us not move along blindfolded, neglecting the other categories. In particular, let us not forget the anti-aircraft and anti-missile missiles. We have heard some terrifying statements about lack of accuracy in *Bomarc* guidance, for example. And what has happened to the *Talos?* Is the *Talos* program bogged down? Last but not least, the latest word on the "incapability" of our *Nike* systems comes from Russia!

Among the publications that our "Russian Editor" scans carefully every month is Sovietskaya Aviatia. This newspaper-type periodical had plenty to say about our *Nike* last month.

It described launching facilities, radar-guidance systems, speed, range and altitude limits of the *Nike* and its installation in conjunction with 90-millimeter antiaircraft artillery.

After reviewing some details, the paper said that the *Nike* missile was very far from modern, because it can hit only single targets.

Sovietskaya Aviatia minimized the value of tests of the *Nike* as reported by the U.S. Army. It said these were conducted against "obsolete piston-engined planes flying at speeds of 200 miles an hour."

"When firing the *Nike* missile under real conditions, where the speed of maneuvering planes keeps changing, the chances of hitting the target become greatly lessened" from the 65 hits out of 100 claimed for the missile, the paper said.

The Russians aren't telling us anything new. Of course, we know the *Nike* is far from perfect. It remains a sad and grim fact, nevertheless, that the Russians are so fully aware of the holes in our air defense system. Certainly it should spur our military leaders to accelerate our advanced anti-aircraft and anti-missile missiles. Obviously, the Russians know that these weapon systems do not exist in this country as yet other than on paper.

There has been some talk about sky-high expenses and non-feasibility in connection with anti-missile missiles. But the majority of our missile experts say an anti-missile missile can be built. Can we afford not to try?

As far as money is concerned, we have noticed that the airmen have programmed $955.7 million for the ICBM/IRBM program for next fiscal year, while "other missiles" will receive $739.9 million worth of attention. How much money will go for *Bomarcs* has not been disclosed. Nor do we have any figures on how much the Army can and will spend on the *Nike Hercules* and *Zeus*. But since the Army's share of the defense budget is microscopic, it appears very little effort is being put into the life-and-death defense weapon, the anti-missile missile.

The drastic slicing of the defense budget is going to hurt all around, of course. In particular, the missile program will suffer considerably. Certainly, there doesn't seem to be any large sum around for an extensive anti-missile R&D program unless Charlie Wilson can dig it up from his special emergency vault. The worst that could happen would be the need for Congressional sanction for such money. Congress probably wouldn't have time to okay this before it adjourns this summer. And this would mean a dangerous set-back time-wise in the anti-missile program.

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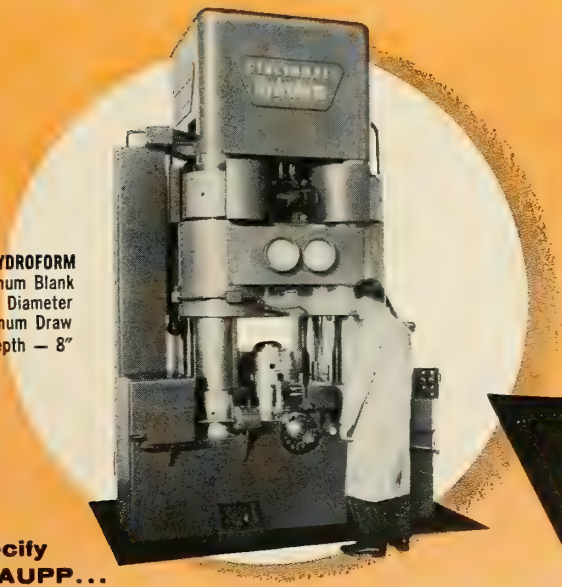
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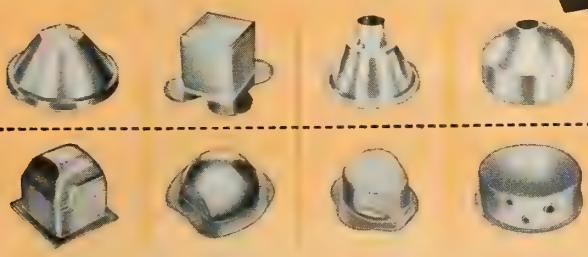
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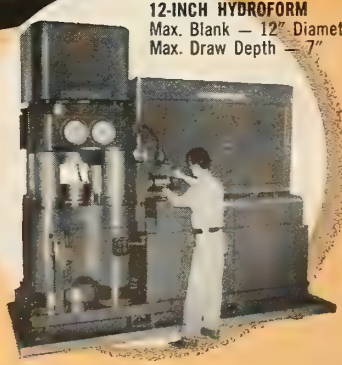


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Washington Spotlight

By Henry T. Simmons

Booming missile activity is a chief factor in the massive over-run in Defense Department expenditures anticipated for the current fiscal year. The Administration predicted a $36 billion spending total for the Pentagon in January; now it looks like the military will go through at least $38 billion before the close of business on June 30. Almost three-quarters of the $2 billion over-run can be traced to the Air Force hardware accounts. The airmen told Congress they expect to exceed their January estimate by $1.4 billion—half the excess coming in the *Atlas*, *Titan* and *Thor* projects. Pentagon has slammed the brakes on overtime payments to contractors in an effort to bring runaway spending under control, but the vital ballistic projects were specifically exempted.

•

Third test flight of the *Navaho* in April was a complete washout. The big missile's multiple booster engines fired for perhaps two seconds, then cut off in response to a wild signal from within the missile. Source of the trouble is known. Meantime, North American has successfully tested a 400,000-pound liquid-propellant booster for the production version of the *Navaho* (if there is one); it would replace the three units of 120,000 pounds each now used with the XSM-64. The new engine, incidentally, is the largest liquid rocket motor known to exist today.

•

Lockheed's supersonic X-7 ramjet test vehicle has evolved into the Q-5, a recoverable drone now under development by the Air Force. Like its prototype, the Q-5 utilizes a ribbon chute to slow down after burnout and lands on its spike nose without damage to the rest of the vehicle. USAF has worked out a deal with the Army at nearby White Sands which permits the soldiers to blaze away at the Q-5 with *Nikes* during the test flights. Army has promised to crank an offset error into its fire control system to assure a minimum number of actual hits on the speedy drone development vehicles.

•

Apropos of the deliberate destruction of the USAF *Thor* IRBM during its second test flight, a tale now going around puts the blame on a faulty radar instrument used by the range safety officer. According to the story, the IRBM was sticking to its course, but was detonated by the safety officer on the basis of false information reported by his instruments. Two other monitoring systems reportedly showed that the *Thor* stuck to its flight plan during its 38-second trip.

•

The Navy isn't happy about its contractual arrangement with Convair for procurement of the *Terrier* ship-launched anti-aircraft missile, now priced at $64,000 a copy. Rear Adm. Frederic Withington, Chief of the Bureau of Ordnance, told lawmakers he would like to have a more competitive type of contract for the bird, but said this is not possible because of the high cost of bringing in a second source. Grumbled Withington: "I wish that I could get out of Convair's pocket with the *Terrier* missile, but I cannot . . . I do not like it, and I have to accept it."

•

On the other hand, the Navy appears to be quite happy with its *Sidewinder* air-to-air missile, which was developed by the Naval Ordnance Test Station at China Lake, Calif. Cost of the infra-red bird has dropped almost 50% over a three-year period. It cost $4,591 in 1956, $3,998 this year, and its estimated fiscal 1958 cost is $3,540.

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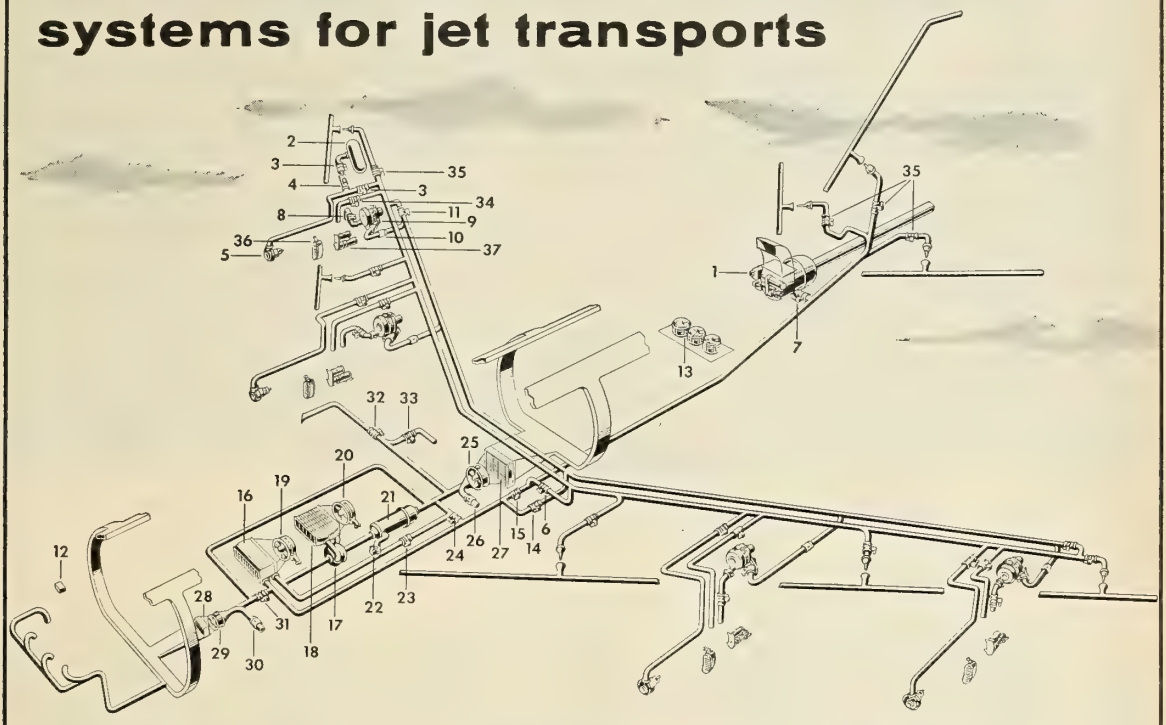
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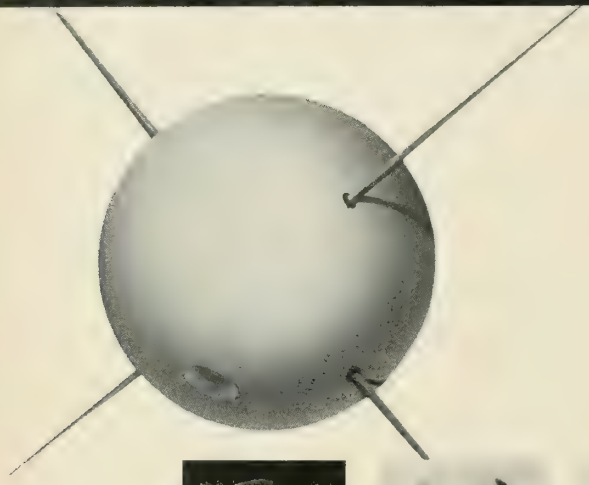
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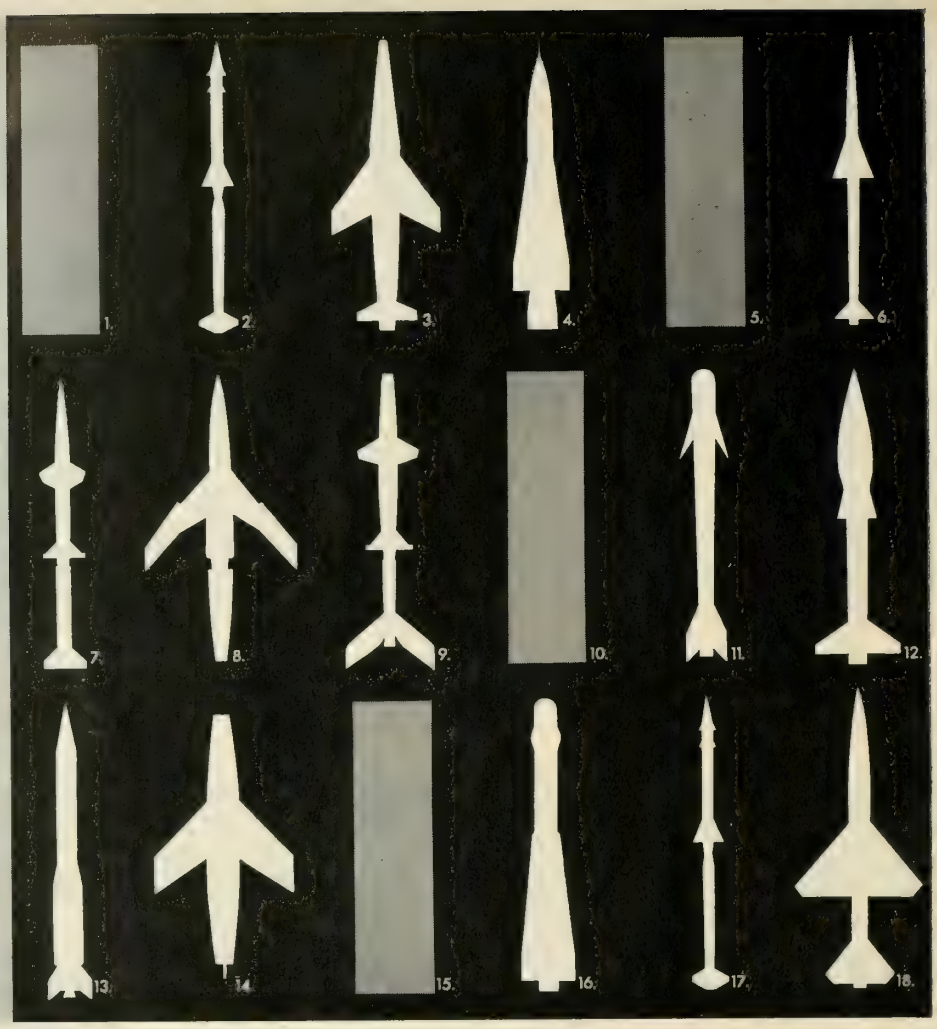
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Known Limits on Chemical Propulsion Systems Demand Early Answer to "What Comes Next?"

By Seabrook Hull

WITHIN LESS TIME than it's comfortable to contemplate—perhaps within a decade—man's demands on flight propulsion systems will exceed the capabilities of any known or imagined purely chemical combination, such as the turbojet, ramjet or rocket. This will be true first of military, later of commercial requirements. It is inevitable not only in the case of practical space flight, but also as flight operations are extended into the upper reaches of the earth's atmosphere.

The military urgency is to maintain air superiority over the Soviet Union. In the absence of specific fact there can be no other assumption than that the Russians are exerting a major effort to transform their long-term interest in astronautics into usable hardware. And who first rules the ionosphere gains an immense advantage over his adversary. In turn, the same is true of outer space.

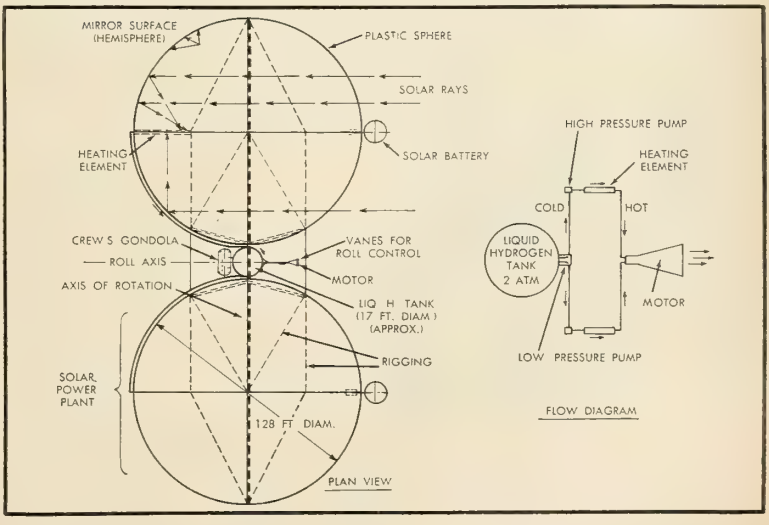
A major consideration in this connection is a propulsion system that has both flexible power and endurance and that is adaptable to the changing conditions of its environment—that can ease readily from the dense lower atmosphere to the ionosphere to free space and back. It should also be as economical as possible in original construction costs, operation and maintenance.

As detailed elsewhere in this issue of m/r, materials will limit combustion chamber temperatures of chemical propulsion systems to about 3000 degrees Kelvin. No matter how efficient a free radical or "zip" fuel reaction may be in heating and accelerating exhaust gases, if it entails higher temperatures, it cannot be used for flights of more than a relatively short duration. They would have to be based on the gradual destruction of the combustion chamber.

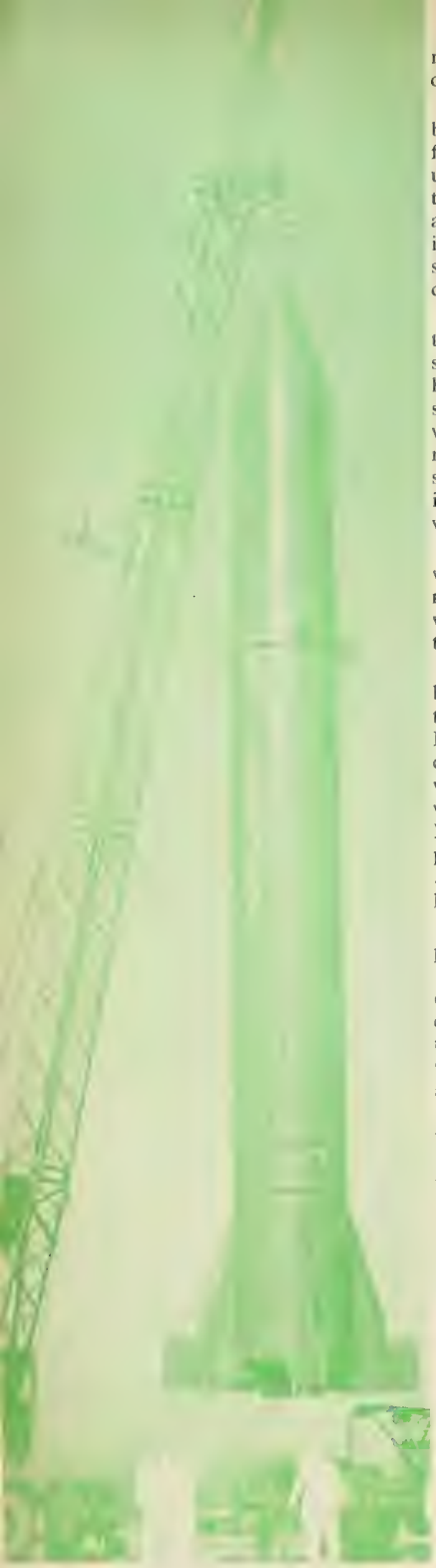
Thus, barring development of a practical means of reconstituting the basic structure of matter so that atoms will take a much stronger grip on other atoms, enabling materials to remain solid to higher temperatures, the absolute theoretical limits of chemical propulsion are known. The very best that can be done, for example with a liquid, solid or jelly propellent rocket is a 40% increase in specific impulse.

For flights about the earth this means a specific and relatively low ceiling on velocity. For travel into outer space it means a prohibitive limit to range and maneuverability. For this reason there is as much urgency as academic interest in determining as soon as possible what comes next.

Among the possibilities are four of purely nuclear propulsion; two electrical systems; one photonic and an as yet undetermined number of others including gravity control, though this last still flounders in the most elementary basic research stages. Not all of these are practical in all three environments —atmosphere, ionsphere, and exosphere. Thus, unless some major technological break-through occurs, as in being able to control local gravitic fields, the propulsion system of tomor-



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row will probably be a combination of two or more.

Nuclear propulsion possibilities break down evenly between fission and fusion. One in each case involves the use of nuclear power as a heat source to expand and raise the temperature of a gas, either air drawn in through an inlet or, in the case of space flight, some light gas that is integrally carried on board.

In the case of fission, the ability to design a reactor to supply the necessary heat exists. What doesn't exist, however, are materials capable of standing up to the temperatures that would come with any material improvement over present thrusts. The one singular gain over conventional chemical systems for airborne operations would be in endurance.

In space flight, even this advantage would be lost, for while the fuel supply might conceivably be "limitless," range would be limited by the volume of gas that could be carried.

In theory, a fusion system could be developed along similar lines, but the same materials limitation applies. It is doubtful if, under present concepts, such a nuclear rocket or ramjet will ever reach wide acceptance, whether it be based on fission or fusion. Particularly in the case of manned applications, the problems of shielding are severe. This is also true in ground handling.

The other two possible nuclear approaches entail use of the nuclear reaction not only to heat and accelerate exhaust particles, but also as the source of the particles themselves. While it is theoretically possible to hold and contain a controlled fusion or fission reaction out in space well aft of the vehicle, thus perhaps obviating the materials problem (the fission bomb generates temperatures on the order of 50 million degrees Kelvin; fusion, 100-to-200 million), this has yet to be done successfully in the laboratory. Work is now in process to attempt it, however. It is a possible answer to some future propulsion needs, but the engineering of such a capability into practical vehicle presents appalling obstacles.

Nuclear power, however, does stand out as the white hope in almost any propulsion system of the future, not as a source of heat or as a rocket itself but as a source of electricity for powering other systems.

The most promising of these at the moment is ion propulsion, where charged particles are accelerated either electrically or magnetically through a kind of inflight linear accelerator. Though there are two distinct schools of thought, due largely to some of the problems encountered with extremely high voltages, magnetic acceleration appears to be more practical. The main disadvantages of either electrostatic or magnetic ion systems, however, are that thrusts obtained are relatively small when thinking in terms of escape from the earth's gravitic field, and as in the case of the earlier nuclear systems, the material to be ionized has to be carried for space flight.

But there are certain distinct advantages. For one, being an electrical rather than a heat engine, there is no theoretical limit to the amount the particles could be accelerated except that imposed by relativity, which is the speed of light. The practical limit, of course, is the amount of electric power which is available.

Such a magnetic accelerator would probably look much like a ramjet, and in fact might actually work as a "zip" fueled ramjet in the atmosphere, switching gradually over to magnetic acceleration as it rose into the ionosphere where virtually all the particles are already ionized.

Nobody seems to doubt that such a vehicle would automatically include a nuclear electric power source. Radiation from the reactor would probably also be used to ionize the propellent.

The photon rocket is a theory. It would use light for thrust. The idea is based on Relativity's assumption that energy (light) has mass, thus permits utilization of momentum transfer.

Theoretical calculations done on photon propulsion indicate that it would be most useful probably for space travel over great distances—outside the solar system.

Another kind of propulsion that might find practical application in free space but within the solar system, as in an artificial satellite or some other vehicle that was never concerned with operation within the earth's atmosphere, would utilize solar power. Large mirrors would gather the sun's light and use it to heat hydrogen or some other light gas.

Research into anti-gravity takes various courses ranging from theoretical calculations and subnuclear studies with bevatrons and the like to simple empirical work on the relationship of gravitic and inertial mass. Basically what still seems to be needed is some break in the laboratory or in the calculations that would point the way in which to proceed.

Gravity remains probably the most baffling mystery facing science today. Solution of that mystery, however, would bring a greater revolution in man's approach to his environment promised by nuclear power.★

FUSION FOR FLIGHT

A major goal in researching propulsion systems of tomorrow is development of an idealized nuclear rocket based on controlled fusion. The first step is to find a means of containing such a reaction. It is believed that fusion occurs at the sun's center at 20 million degrees and at a pressure of 400 billion atmospheres. At normal pressures it's estimated that the thermonuclear reaction would be self sustaining at about 100 million degrees.

In this connection it's significant that Britain's Atomic Energy Authority is building equipment at its research establishment at Harwell, Buckinghamshire, to do just this. It will consist of a "huge" glass container, in the center of which the reaction is to be contained by magnetic fields. The AEA claims to have already produced temperatures of two million degrees in small scale equipment without having caused damage to the container.

Cold fusion is another possibility. This involves catylization by the negative mu meson of thermonuclear reaction at reasonable temperatures, but with a full release of energy. This reaction has been observed by Dr. Luis W. Alvarez in a hydrogen bubble chamber at the University of California at Berkeley. Provision of an adequate, controllable source of negative mu mesons presents formidable problems. This work is still at the level of basic theory.

Meanwhile work is continuing in Britain, Russia and the U.S. to contain the hot reaction magnetically. An excellent summation of U.S. efforts in this field was recently given by Chairman of the Atomic Energy Commission, Lewis L. Strauss:

"In seeking the means of heating and confining the ionized gas, the scientists in the Sherwood Program (The Atomic Energy Commission's code word for the controlled thermonuclear program) are working with what some of them termed a 'Magnetic Bottle.'

"Electrically charged particles can be controlled by magnetic lines of force, supplied by suitable coils or by powerful electrical currents passing through the plasma itself.

"The magnetic lines of force cause any ionized particles to be deflected whenever it tries to cross them. The particles, instead of crossing the lines, are compelled to spiral around them. Thus, with the 'Magnetic Bottle' we seek to throw up invisible barriers to prevent the plasma from coming into contact with the walls of the tube.

"The scientists believe it will be possible, in such a system, to contain the plasma at a temperature of more than 100-million degrees, while the walls of the container remain relatively cool, or at least well below the melting point of the material.

"Here we come up against another baffling problem, perhaps the most difficult problem of all. 'How do we set about making the Magnetic Bottle as nearly leakproof as possible?' When the magnetic lines are employed as barriers against escape of the plasma, pressure is built up inside the lines with resulting instability of the plasma. The lines behave much like rubber bands. They're inclined to bend inward and let the plasma flow out around them. Our scientists are hard at work at the present time on this problem of instability.

"The magnetism must be just strong enough to confine the ionized gas at the right density and temperature and to maintain that confinement long enough for a reaction to take place. Since the reaction raises the temperature, the magnetic field must have variable qualities. It must grow stronger when necessary to keep things in balance. We must be able to draw power out of the thermonuclear machine without disturbing its tricky balance.

"In our research on this particular problem, some of our scientists are working with what is known, in the parlance of the laboratory, as the 'pinch effect.' They are trying to regulate the strength of the magnetic field, and obtain a direct interplay between the magnetic energy and the energy of the plasma; in other words, to produce a balance.

"A heavy current, such as a bolt of lightning, can squash a copper drain pipe through which it passes. The 'pinch' is the same phenomenon in a gaseous discharge. This is based on the familiar fact that parallel circuits carrying currents in the same direction attract each other.

"In applying this fact to controlled thermonuclear research, the scientists are seeking through heavy discharges of electricity to 'pinch' the atoms of the plasma together and suspend them in a thin line away from the container.

"Interesting results are being obtained in this particular effort, but the problem is far from being licked; perhaps even years from its solution."

"We have produced very high temperatures for the briefest fraction of time from these 'pinched' discharges. But the time during which these can be maintained, at present, is reckoned only in microseconds. As yet, the 'pinch' is not fully stable.

"And, of course, to be valuable for the purposes of producing power, the atoms to be fused together must be held in a tight bundle long enough and at a temperature high enough for an appreciable number of them to fuse. Furthermore, the energy output must far exceed the amount of energy that is required to produce the reaction.

"As I stated at the beginning of my remarks—I should like to emphasize again—we are making progress, but the problems are formidable."

Three nations have made public announcements that they are working towards controlled nuclear fusion. They are the U.S., Britain and the Soviet Union. The latest position report on the British program is noted above. The Russians, as usual say little. However, it's known that their thinking in this connection, at least, is very advanced.

U.S. progress can best be described as at the stage where scientists are seeking to get to a stage comparable to the first fission reactor which was built by Enrico Fermi's group in 1941. As of April 1, according to AEC's Chairman, "There has been nothing yet that could be described as a major breakthrough."

Efforts to achieve controlled fusion, however, are getting a $10-million boost from private industry. The Texas Atomic Energy Research Foundation last month signed a contract with General Atomic Division of the General Dynamics Corporation for a four-year research program in the field of controlled thermonuclear reactions. The Texas foundation is supported by private electric power companies operating in the Southwestern United States.

Though their objective is controlled fusion for the production of electric power, any such reaction that worked safely and economically would be a major step forward in the search for a fusion rocket. Research under this project will be carried on at General Atomic's new multi-million dollar John Jay Hopkins Laboratory for Pure and Applied Science at San Diego.

Atomic Power Packages For Missile Launching Sites

AS MILITARY strategy and tactics enter the era of operational missiles like *Snark, Navaho, Bomarc, Thor, Jupiter, Atlas* and *Titan,* problems switch from exciting to essential.

It's one thing to build a missile and test fire it from point A to point B. It's quite another to develop reliable, mobile support equipment for servicing and firing missiles from any point in the world as required by a military situation.

The primary task is development of a source power to keep an operational missile base functioning. There are crews' quarters to be supplied with heat and light; radar and other electronic gear to be powered; gantries and launching gear to be powered; oxygen to be separated from the air, purified and liquified; fuel and oxidant to be pumped, etc.

Ideally this power unit should be air transportable—perhaps ultimately air dropable—and it should contribute a minimum to logistical supply problems. It should be an atomic power plant.

Recently the first test prototype of just such a power plant began operating at the Army Engineers' Research and Development Laboratory at Fort Belvoir, Va. Heavily encumbered with extra-special safety shielding and precautionary measures because of its proximity to the nation's capital, the Army Package Power Reactor, APPR-1, is anything but packageable and anything but air transportable. However, its basic components, stripped of the probably-unnecessary additional "catastroph shielding," form the basis of just such a mobile unit.

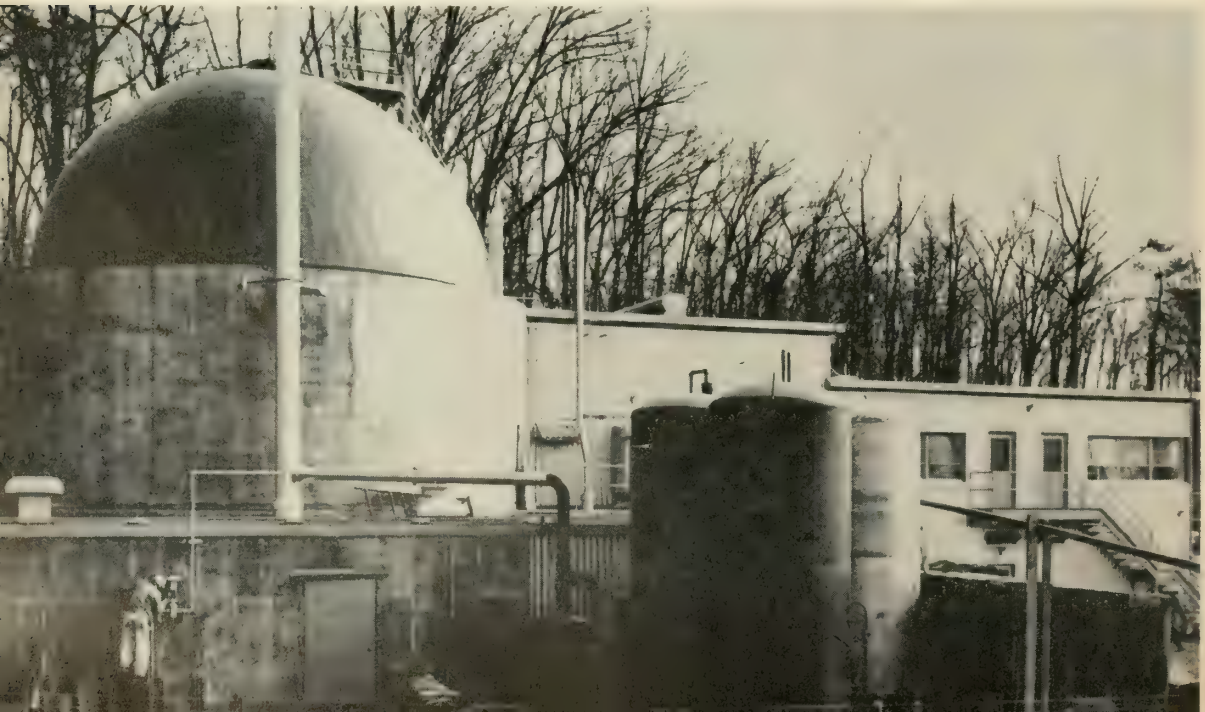
At the present time a joint Army-AEC program has been established with the objective of developing a family of nuclear powerplants to meet the requirements of Army, Navy and Air Force. The large plants will be capable of use in areas where logistical support is difficult, costly, or vulnerable to interruption by enemy action.

Smaller plants are to be developed as mobile or semi-mobile compact powerplants for support of military operations in theaters of operations and for emergency power requirements.

The great military advantage of nuclear power is the elimination of all but a small fraction of the logistic effort which otherwise would be required to transport and store bulky conventional fuel.

The Army Package Power Reactor, APPR-1, is designed to operate at full power for a year and a half on a single charge of nuclear fuel, which

General view of the Army Package Power Reactor, with the vapor container at left. This heavy concrete dome is a major part of the extra precautionary measures taken because of the plant's proximity to the nation's capital.



is smaller than a barrel and weighs only a few hundred pounds. Over the same period a comparable conventional plant would consume some 60,000 barrels of fuel oil, equivalent to the capacity of a medium-size tanker.

Our Arctic base system is a good example of a power requirement where use of nuclear power offers a great advantage. Ship supply is seasonal, limited to the short ice-free period of less than 60 days each year. Unfavorable weather may completely throw out of adjustment the re-supply schedule for any one year to say nothing of what enemy attack would do.

In more temperate climates there are also bases which in ordinary times are subject to delay in re-supply due to their remoteness. In time of war their existence at the end of long, vulnerable supply lines is precarious.

The use of nuclear power would reduce total supply tonnage required to support many of these bases to less than half of that required when using conventional powerplants.

In addition to the present requirements, a situation of war would multiply power requirements for military operations and disaster relief. The use of nuclear power to satisfy these demands would simplify the difficult logistic problem which they create.

The military need for a family of such nuclear powerplants was established as the result of a series of investigations begun during 1952 by the Corps of Engineers.

As a result of these studies, the Army recommended the construction of a prototype nuclear powerplant in the U.S. In late 1953 the Defense Department approved the Army's plans and requested the Atomic Energy Commission to undertake the necessary development program. Shortly thereafter a joint organization was established to coordinate AEC and DOD activities in the Army Nuclear Power Program.

The Corps of Engineers representing the Army, has been given the responsibility for development of the non-nuclear portion of the plant on behalf of the Department of Defense. The Army Reactors Branch within the AEC fulfills the Commission's responsibilities for development of the reactor and associated equipment.

Three general categories of military nuclear powerplants are already being developed under this program. The first category covers fixed plants to furnish electric power and heat at remote and relatively inaccessible military installations where the cost of conventional fuel is high.

In the second category, development has been started on mobile nuclear powerplants for support of military operations and for emergency power systems. The objective is to develop plants which can be mounted on trailers, railway cars or barges, with essentially no requirements for replacement fuel or water for the duration of military operations. Two major projects are now under way.



This artist's conception shows how simplified such an atomic power plant might become once it has been stripped of such things as class-rooms and all but the most essential shielding.

The third category covers special-purpose nuclear reactor systems. Feasibility studies are being conducted on nuclear propulsion of land vehicles. The Transportation Corps is directing particular attention to a nuclear-propelled "sno train" suitable for overland supply of arctic bases.

A special-purpose reactor is about to be constructed to furnish ionizing radiation for use by the Quartermaster Corps in the irradiation and preservation of food.

Army Package Power Reactor is the first prototype of a field, military, nuclear power plant to be built as a result of this program. It has been constructed to accomplish three broad objectives:

Solve technical construction and operation problems associated with a reliable nuclear power plant.

Provide firm cost information, operating parameters and engineering test data necessary to adapt the system to a remote location.

Provide a training facility for troops and specialists who might eventually be required to operate and service remote plants.

Early in 1954 the Commission invited proposals from thirty-three major industrial firms for complete design, construction, and test operation of a prototype nuclear power plant, the APPR-1. Eighteen proposals were received in response to this invitation, and in December of 1954 the contract was awarded to ALCO Products Incorporated. The contract provided for guaranteed operation, to be established by a 700 hour performance test and a six-month operating test during which the plant would be producing usable power. The provision for a fixed price was the first such agreement in the awarding of reactor contracts.

After a survey of various locations within the U.S., and with the approval of the Atomic Energy Commission's Advisory Committee on Reactor Safeguards, the Engineer Research and Development Laboratories area at Fort Belvoir, Va., was selected as the plant's site. Since it will be in a heavily populated area, elaborate precautions have been taken in the design to insure maximum safety of operation. In addition, the reactor core will be located within a container designed to retain all radioactivity even in the event of a major incident.

The plant's design as conceived by the Oak Ridge National Laboratory and as detailed by ALCO, is based upon a pressurized water reactor operating at a power level of 10 megawatts. Pressurized water circulated through the reactor, is heated and passes to a heat exchanger where it transfers its heat to a secondary loop of water.

This heat converts the secondary water to steam which is then used to drive the turbine. The net electrical output of the plant will be utilized to supplement the Fort Belvoir power distribution system.

Construction of the plant was begun on October 5, 1955. The 700 hour performance test is scheduled to be completed before July 10, 1957. Trained men from all three military services will assist ALCO in starting and operating the plant in anticipation of the day when the plant will be turned over to the military. Experienced cadres for future nuclear power plants will be taken from this group of military operators.★

International Control of Outer Space

What Will Outer-Space Missiles and Advanced Earth Satellites Mean to World Security?

By Dr. Donald W. Cox

IN THE LONG HAUL our safety as a nation may depend upon our achieving space superiority . . . Several decades from now the important battles may not be sea battles or air battles, but space battles . . . We should be spending a certain fraction of our resources to insure that we do not lag in obtaining space supremacy."

Major General Bernard A. Schriever, Commander of the Western Development Division of the Air Research and Development Command, USAF, made this statement before the first government-industry sponsored "Space Symposium," held in San Diego last February.

The significance of this challenge by an Air Force official, who, probably more than any other man alive, is closer to the realities of the coming space flight age, is worth pondering. With the announcement of the first successful IRBM launching and hints that the first earth satellite might not be too far off, it is not too early to consider possible future legal problems involving ownership and use of the last unexplored frontier—space.

A noted international lawyer, Wilfred Jenks of Great Britain, recently summed up the need for promulgating a body of space law that will be mutually accepted by all nations.

He wrote: "It is not premature for international lawyers to give some preliminary consideration to the problems which will confront them as a matter of urgency if the current efforts of scientists and engineers, specializing in astronautics and electronics, should suddenly achieve a dramatic success . . . There are circumstances in which the possibility of developing the law on sound principles depends primarily on initiative being taken in the matter before de-facto situations have crystallized too far. The exploration and exploitation of space may proceed as slowly as the course of polar exploration or the conquest of Everest; they may however, develop as rapidly as the utilization of atomic energy, or of rocket propulsion. It is wise to be prepared for any eventuality."

With technology beating a steady tom-tom on the door of outer space, a search for a rational and acceptable space control theory is essential to help insure civilization's survival.

Theories of Space Control

In the past few years, several renowned international lawyers have taken an interest in space law in its embryonic state. Their theses have appeared in such journals as: MISSILES & ROCKETS, *Jet Propulsion, The Journal of Air Law and Commerce, The Nation's Business* and *The International and Comparative Law Quarterly.*

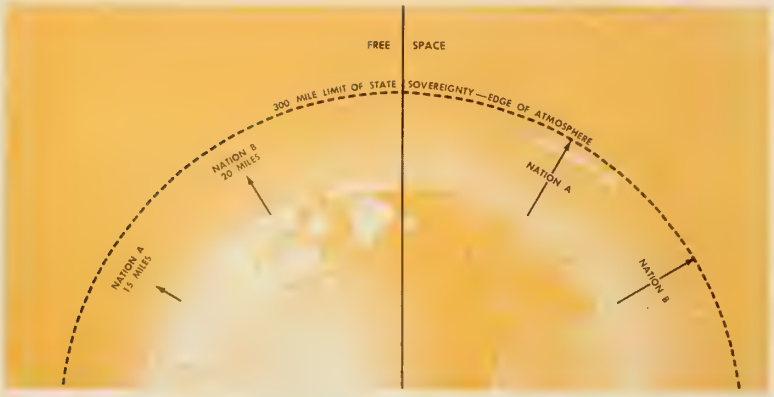
Excerpts and briefs of four of the leading theories will be analyzed here:

Oscar Schachter, an English international lawyer and a Director of the UN General Legal Division has fathered the Airspace Theory, which is adhered to by many U.S. experts.

Schachter's theory holds that national sovereignty upwards is limited to navigable airspace which will reach a maximum of 40 miles in the future.

This doctrine sets some legal precedents. This is evident in the multilateral air treaty agreed to by 49 nations at the Chicago Convention of 1944. Although this treaty is adhered to by most of the civilized world in granting exclusive sovereignty to airspace over national territories, it does not define the term "airspace." Because of this, there is no general agreement of height limit to sovereign control by the leading nations.

This theory is unrealistic since nations today do as they please except where treaties or their own best interests dictate otherwise. Space law like international law, therefore, will probably develop according to the relative



Shachter's "Airspace" theory—State sovereignty is limited to the height at which aircraft and balloons can operate.

Jenk's "Free Space" theory—State sovereignty is limited to activities within the limits of the earth's atmosphere only.

power of various nations instead of through any master plan. Failure to perceive the power realities is the major flaw in the workability of this theory.

Jenks' Free Space Theory

Mr. C. Wilfred Jenks, L.L.D., an Associate of the Institute of International Law at Cambridge, England, has written "International Law and Activities in Space," (1956), in which he propounds a *Freespace Theory*. In a 6-step program, he theorizes that:

(1) The appropriation of outer space by any one nation is impossible because of its nature. State sovereignty is limited to activities within the atmosphere with control similar to that "exercised in territorial waters or over a wider maritime frontier belt."

(2) Jurisdiction over space activities should be vested in the U.N.

(3) Failing this, jurisdiction should be determined by analogies to maritime and aviation law.

(4) Rules will be necessary to protect national authorities in space.

(5) The sovereignty of the moon should be vested in the U.N.

(6) The natural resources of the moon should be vested in the U.N.

Although Jenks' theory appears to be more realistic than Schachter's from a power competition standpoint, it, too, would establish an illogical power control limit at the edge of the atmosphere. Will those nations which perfect a device to penetrate outer space submit to such a limitation?

Some moralistic nations might acquiesce to such a hypothetical limit, but not immoral ones.

Haley's International Unanimity Theory

Andrew Haley, General Counsel for the American Rocket Society and one of the two most prominent international space lawyers, has written several articles on space law. In one of his more comprehensive tomes, he propounds a theory which we will call the International Unanimity Theory.

Haley theorizes that areas above the atmosphere (roughly 300 miles and up) *might* be subject to sovereign control by one or more nations. But the now historic fact that no nation objected to the plan to send earth satellite vehicles over their sovereign territories during the IGY, leads Haley to conclude that the sovereignty of space has been, ipso-facto, given to the U.N.

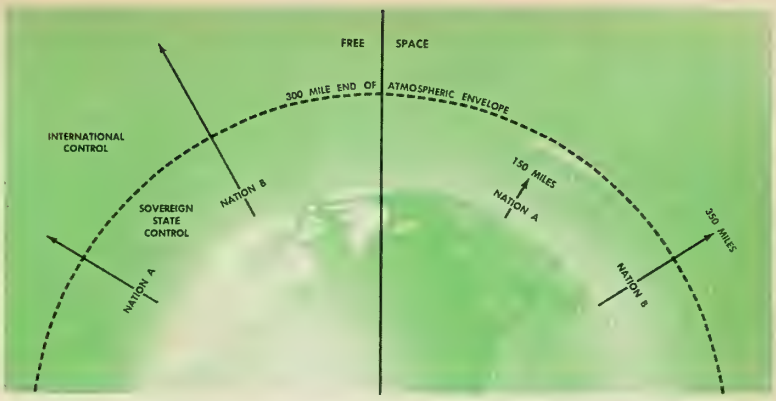
This mutual understanding will undoubtedly continue as long as outer space is to be used for peaceful, exploratory purposes, or as long as no one nation has the ability to intercept a satellite or space missile. Haley feels that the "scientists in the IGY Program have benefited mankind as a whole in a field where the lawyers might well have failed."

He says that the present body of international law, based on maritime jurisdiction and restricted aviation law is entirely "hostile" to the realities of space flight and is therefore inadequate. This inadequacy applies to both civil space flight rules and rules of space war. This is why a new system of space law, under the U.N., is needed.

Haley's plan calls for a mutual agreement on space communications. He rules out the possibility of any nation, with outer space capability, breaking a U.N. agreement and offers no plan if such an event should occur, putting his faith in the peace making machinery of the U.N.

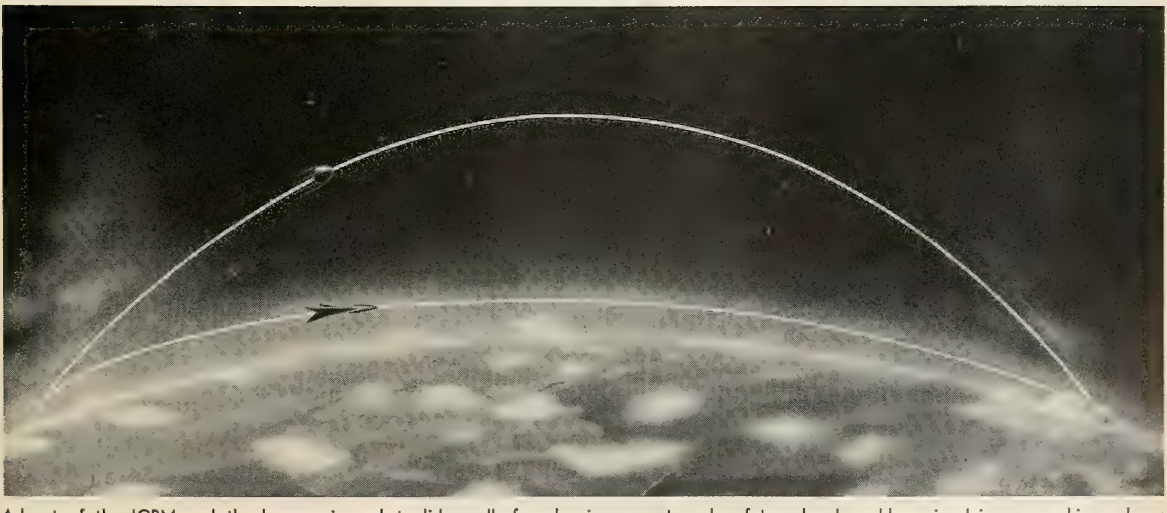
Cooper's "Control" Theory

John Cobb Cooper, the Dean of American International Air Lawyers,



Haley's theory—Extra-atmosphere "might" be subject to sovereign control; with international control for peaceful purposes.

Cooper's control theory—Sovereignty extends as far as a nation is able to govern those events occurring over its territory.

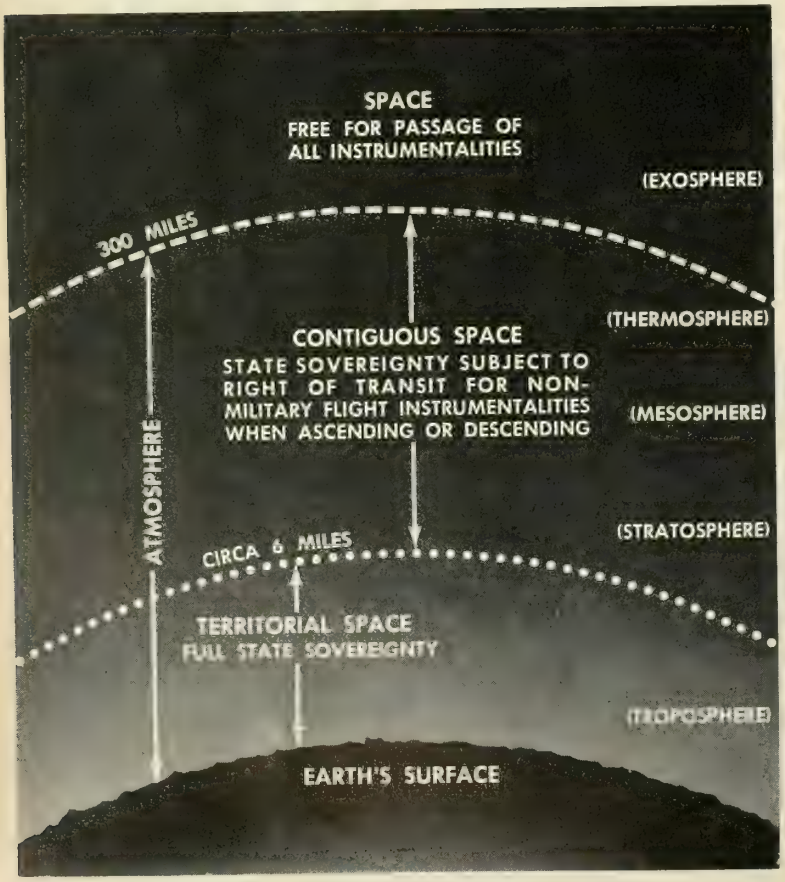


Advent of the ICBM and the hypersonic rocket glider calls for planning now to solve future legal problems involving ownership and use of space. Regulations are needed to insure peaceful exploration of our last frontier. One theory calls for a uniform code covering such activities as: instrument-carrying missiles and satellites, space radio communication, navigation, space stations and passenger transport.



An artist's view of the artificial earth satellite and the moon as seen from outer space. Fact that it is to be sent aloft during the IGY program should spark public interest in space law.

formerly Chief Counsel for Pan American World Airways and currently a member of the Institute of Advanced Studies at Princeton, has propounded a Power Theory of Space Control, which is unlimited in its scope. It is based on the assumption that a nation's ability to govern activities over its territory varies only with the nation's ability to penetrate up into space.



Cooper's "Tri-space-level" theory, as adapted from the Journal of Air Law and Commerce.

According to this theory, one nation may not be able to launch a vehicle which can escape the confines of the earth's atmosphere—while another one may be able to reach out well beyond the space frontier.

Realizing the efficacy of potential future space rivalry, Cooper proposed that an amendment to the 1944 Chicago Convention be adopted to restrict space power enthusiasts.

He feels that full state sovereignty could be maintained in the territorial space between the ground and a 10 mile high altitude in the troposphere. However, he felt state sovereignty should rule between the 10 and 300-mile levels, in what he termed "contiguous space," subject to the right of transit for flight instrumentalities when ascending or descending.

Space itself, he feels should be kept free for the passage of all intrumentalities, military or civilian, with any nation having the right to launch space flying vehicles as high and far as they wish.

Such an eventuality was predicted by General Schriever at the first Space Symposium last February, when he supported the concept of using ICBMs as a lever for the U.S. exploration of Space. He emphasized the direct military importance of space to the U.S. and added that the nation's prestige as a world leader "might well dictate that we undertake lunar expeditions and even interplanetary flight when the appropriate technological advances have been made and the time is ripe."

However, according to Haley, Cooper's rule of space control "presents the disquieting prospect that a state with extraordinary scientific resources could extend an empire into deep space. It is a counterpart of the might makes right principle which pervades maritime law and kept England mistress of the seas for centuries. This rule . . . imposes a limit over national sovereignty." This would give Cooper's theory an empirical limit.

The trouble with Cooper's control theory is that sovereignty is limited only by relative state power.

Nations that possess the capability to blast any satellite or missile from the skies overhead, regardless of their purpose, could do so at will, while other nations would be helpless to do anything about various types of spacecraft passing over their territory or to intervene in support of a friendly space exploring nation.

The concept of space ownership as envisaged by these four theorists does not call for a universally agreed space code.

However, certain common assumptions seem to be held by all the theorists studied, regardless of their differ-

ences on application of individual theses of space law and rules.

However there is general agreement that there is an inherent conflict between the doctrine of freedom of the seas and that of state sovereignty over territorial airspace. Rules for the former seem to be more applicable to outer space vehicles than the latter.

The inability of present rigid "air curtains" over fixed territorial boundaries, to adapt themselves to the constant changes of spatial relationships of a space vehicle, due to the rotation of the earth, is the logical determinant which negates the present state sovereignty air law.

All four theories propose some limit on national air sovereignty, which should be enough to seal the coffin on this present doctrine and to prevent its application to space flight.

Because missiles and space stations would be constantly changing positions, new, progressive legal regulations are needed to insure the peaceful exploration and exploitation of space.

Jenks proposes eight such regulations which still need to be written and agreed upon by all the nations, in a progressive series of steps. International uniformity will be necessary in most of these rules to guarantee civilized activities in space and to keep space instrumentalities under proper control. The legal regulations which he prescribes would encompass the following:

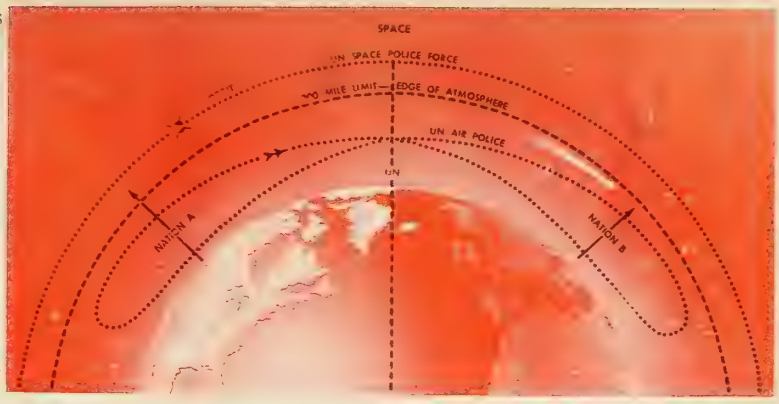
(1) Instrument-carrying missiles and satellites; (2) A Navigation code in space; (3) A space radio-communication code; (4) Certification of space navigators and other space persons; (5) Rules governing construction of space stations, bases, etc.; (6) A space rescue code; (7) Rules governing the carrying of passengers and goods; (8) Rules determining the law applicable to legal transactions occurring in space.

In preparing an ultimate space law code, we can learn much from the "freedom of the seas" maritime law established by Grotius.

Need for a New Theory

There is an important omission in all four theories of space control: recognition of the need for a UN space police agency to control and patrol the interplanetary regions.

The precedent for the feasibility of such an international space police force has been the relative success of the recently organized first international police force which has been operating on the ground only in the disputed areas between Egypt and Israel. To make sure that any power-mad nation or nations does not usurp their free space prerogatives, a police force will have to come into being. The vehicles could be supplied by the major earth national powers, but the crews could be composed of space police-navigators recruited from secondary or neutral UN powers (much like the present Suez Police Force). Space control stations on earth could also be supervised and monitored by UN designated teams, even though constructed and owned by sovereign nations.



An "International Space Force" theory would have both United Nations air police and a UN space police force.

Without a permanent UN space police organization, in advance of any space dispute, Haley's *International Unanimity Theory* is in danger of being compromised.

Haley hits at the necessity of guaranteeing the joint world ownership of space in the following statement:

. . . "These principles must necessarily have only interim application, for there must be a basic principle that the regions beyond the aeropause may be called by no nation; mankind may make only such utilization of space as will be for the benefit of all mankind and to the detriment of no other intelligent creature."

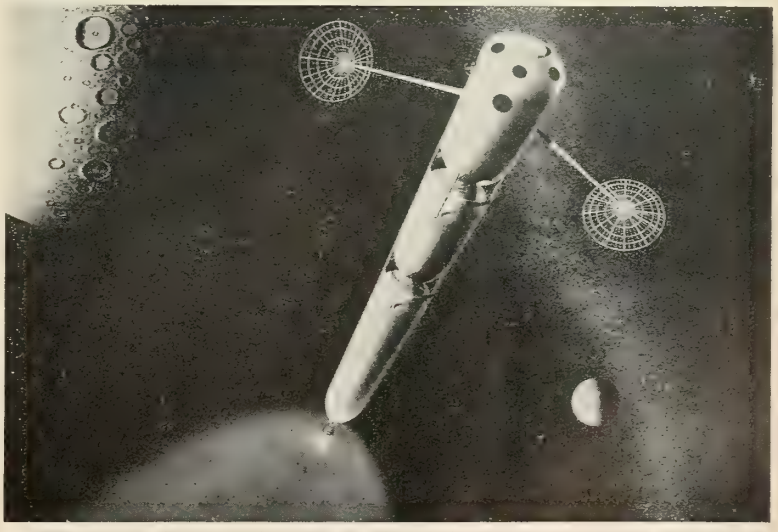
The expansion of the first UN police force's duties in the Suez dispute points up the faith which the Free World has in such an organization.

The extension of the UN's control to the upper air and outer space regions with its own air and space force is a need which merits immediate consideration for initial planning purposes.

An international air-space police force could be established in a series of steps, with the conventional UN air police force patrolling the air over the Poles, oceans and uncivilized desert and jungle regions.

Such experience would provide the force with valuable insight into the greater problems with which they will have to cope when their duties are extended to the upper atmosphere and eventually to outer space.★

Note: The views expressed in this article are the author's and do not necessarily reflect those of The Martin Co.



When space becomes a highway, who will control the traffic.

SHIPS for SPACE

Some systems considerations on high performance power plants

By Dr. Peter A. Castruccio

Westinghouse Electric Corporation
Air Arm Division

FIRST ESSENTIAL for practical space-flight is an economical propulsion plant. Present-day power plants are almost adequate for exploratory expeditions, but they do not fulfill the requirements for military usage of spacecraft. Military vehicles should possess mobility: to maneuver essentially at will, to deploy in formations as required by their mission, and generally should adapt to a wide variety of kinematic and dynamic conditions as may be dictated by the maneuverings of an intelligent adversary.

Among the missions which military spacecraft will be required to perform are: reconnaissance of enemy territory, bombing missions, rescue operations, refueling in flight, and battles with other ships, stemming from the adversary's desire to thwart these missions.

These requirements necessitate that military ships have a sufficient "acceleration reserve" above and beyond the bare minimum necessary for takeoff and subsequent landing. These craft must be able to endure prolonged periods of sustained, even though not intense, acceleration.

The basic, and only propulsion system so far considered practical for space flight is the reaction principle, based on the law of conservation of momentum. According to this law, if a body of mass M + m ejects a fragment of itself of mass m with a speed v, the body M will receive a "recoil" speed equal to $\frac{mv}{M}$.

This is true for a "one-shot" ejection. If the ejection becomes continuous, as in a rocket motor, the law of recoil states that:

$$a\ M = q\ v \qquad (1)$$

where a is the acceleration imparted upon the mass M, v is the jet velocity, and q is the mass ejected per second (flow). It should be noted that (1) is only true instantaneously: as time progresses, the mass M will constantly diminish by the amount of the ejected mass, so that the acceleration will increase as time goes on (if q and v are maintained constant).

From Equation (1) we derive this expression for the acceleration:

$$a = \frac{qv}{M} \qquad (2)$$

This means that a ship of mass M can theoretically achieve any desired acceleration by using a sufficiently high qv product.

A space vehicle with high acceleration reserve should be designed to use as little reaction mass as possible in order to make the reaction mass last for as long as possible.

A reduction of reaction mass can be obtained by an increase in the jet velocity v, maintaining the product qv constant. Equation (2) shows that as far as acceleration capabilities are concerned, we can trade indifferently reaction mass for speed of ejection.

The Power P required from the ship's power plant to eject a flow of

TABLE I

Spaceship Loaded Weight = 100 Tons
Mass Ratio = 1.09
Reaction Mass = Mono-ion H^2

Acceleration	Power Output HP	Accelerating Voltage	Flow	Time to Burnout	Burnout Velocity Miles/Sec.	Time Required to Cover 50 Million Miles—Start From Rest, End at Rest
1g	2 Billion	100 KV	11.5 Oz/Sec	8.6 Hours	194	5.8 Days
0.1g	200 Million	100 KV	1.15 Oz/Sec	86 Hours	194	7.8 Days
0.01g	20 Million	100 KV	0.12 Oz/Sec	36 Days	194	21 Days
1g	70 Million	100 Volts	22 Lbs/Sec	1000 Sec	6	200 Days
0.1g	7 Million	100 Volts	2.2 Lbs/Sec	10,000 Sec	6	200 Days
0.01g	700,000	100 Volts	3.5 Oz/Sec	1.16 Days	6	129 Days
0.001	70,000	100 Volts	0.35 Oz/Sec	11.6 Days	6	66 Days
0.0001	7,000	100 Volts	0.035 Oz/Sec	116 Days	6	244 Days

The practical realization of a high performance rocket ship hinges upon three basic developments:

1. A means to achieve high jet velocities.
2. Development of power plants of high specific power.
3. Development of energy sources of high specific energy.

A practical means to achieve high jet velocities is the acceleration of charged electrical particles.

A body of mass m and charge e, in passing through an electric field of V volts acquires a speed:

$$v = \sqrt{2\frac{eV}{m}}$$

mass q per second at speed v is ½ q v^2. By substituting (2) in this latter equation, it is easy to show that the required power is:

$$P = \frac{1}{2} M a v$$

This means that, for a given ship mass and acceleration, the power required from the ship's power plant increases directly with jet velocity (and inversely with the flow of reaction mass): thus a reduction in reaction mass can be achieved only at the expense of increased power.

Let us also assume for simplicity, that the reaction mass required for the trip is small compared with the ship's own mass, so that the simplified equations given above can be used; consider now two ships, starting from the same point, and of identical masses. If both ships travel with the same acceleration, one with a low jet velocity, the other with a higher jet velocity, both ships will cover the same distance in the same time, in other words, both will perform the same amount of external work. The ship with higher jet velocity will use a greater amount of energy than the other. Precisely, the energy used is proportional to the jet velocity.

This points out a basic law of the rocket motor: more power and more energy is required to perform the same amount of external work if the reaction mass must be economized.

A measure of basic rocket efficiency can be had by consideration of the following simple case. Consider a ship in a gravity-less field, starting from relative rest, and required to travel from Point A to Point B, a distance d apart.

Assume the trip is performed by constantly accelerating with acceleration a for half the distance d, then decelerating at the same rate until B is reached with the ship at rest. (This is almost optimum from the standpoint of power reduction.)

Under these conditions, the external power required to perform the trip is:

$$P_e = Ma^2$$

The power required to propel the ship via the rocket mechanism (the actual power the rocket must expend) equals:

$$P_r = Ma^2 \times \frac{M}{2q}$$

The ship's power must be greater than the external power by a factor $\frac{M}{2q}$

The quantity $\frac{2q}{M}$ can be considered as a measure of the basic "power efficiency" of the rocket propulsive system. The efficiency is obviously lower, the lower the reaction mass ejected. We reach the following general conclusions:

— Reaction mass can be economized by increasing the jet velocity.
— Any reduction in reaction mass must be paid for by an equivalent increase in energy expenditure.
— Any reduction in reaction mass must be achieved by a corresponding increase in power capability of the power plant.

It follows that a ship capable of sustained accelerations with economy of reaction mass must possess an energy source with high energy per unit weight, and a power plant capable of high power output per unit weight. Nuclear reactors satisfy the energy storage requirements; however the power plant is another matter.

As an example of the quantities involved, consider a ship of 100 tons weight (about the size of a DC-8), to be propelled at an acceleration of 1g, with a total reaction mass of 10 tons. At a flow of 1 kilogram (2.2 lbs.) per second, the power output required will be 700 million HP. Such a ship will possess almost three (3) hours acceleration capability.

Starting from rest in gravity-less space, this ship could attain a speed of 35 miles per second, and still have sufficient reserve mass to decelerate again to rest. The total energy required to exhaust the reaction mass is equivalent to 25 lbs. of U238 at full efficiency.

By contrast, the external power required to do the same job is only about 13,000 HP.

These figures point out the huge inefficiencies of the rocket mechanism, and the tremendous discrepancies between energy requirements—which are low in terms of nuclear sources—and power requirements, which are great.

The power requirements can be reduced by either increasing the flow (the power reduces directly as the flow is increased) or by decreasing the acceleration (the power reduces as the square of the acceleration). Thus, if our ship be limited to a 0.01g acceleration, with the same flow, the power output is reduced to 70,000 HP, and the energy is reduced by a factor of 10,000. The terminal velocity reached by the ship will be only 0.7 miles per second. Table I, above, gives various relationships pertaining to the assumed ship model.

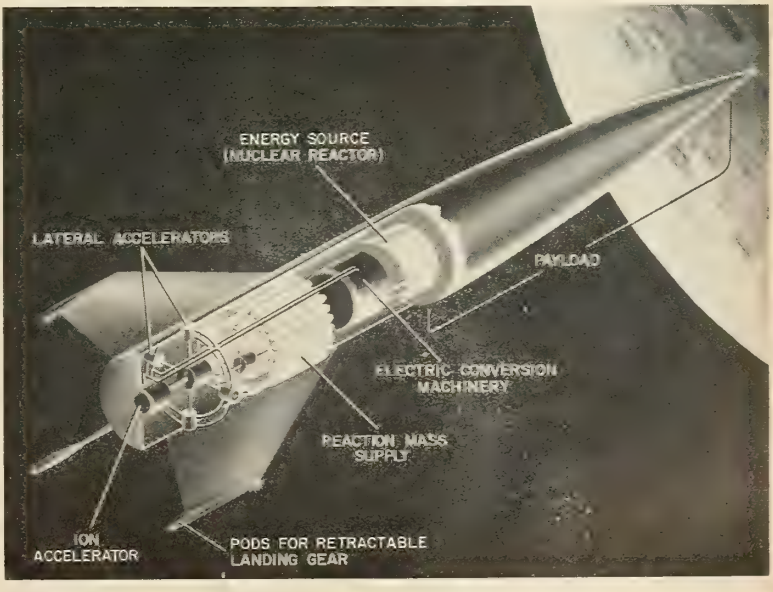
The speed is seen to depend on the charge-to-mass ratio e/m. Thus lighter particles will be speeded up more than heavy particles.

Electrons can be accelerated at higher speeds than any other particle. Electrons, however, do not constitute desirable reaction material because their total mass is but a small fraction of the mass of even the lightest substance.

In a given amount of electron-emitting metal, for instance, less than $\frac{1}{100{,}000}$ th of the metal's mass is composed of electrons.

Even if it were possible to strip a given amount of material of all its electrons, the mass of electrons thus gained would be insignificant with respect to the total mass of the material. At such low masses, extremely high jet velocities would be required and thus the power requirements would be enormous.

The converse process to electron generation is ion generation. Ions possess practically the entire mass of the reaction material, and can still be



Proposed layout for an ion-propelled space vehicle.



An ion propelled space ship accelerating at 1 g would have a power output of some seven million horse-power. A mythical cable car to the moon accelerated from an outside source would take 13,000 horsepower.

accelerated to high velocities by reasonably strong fields.

In theory, the basic concept of the ionic rocket motor is simple: the reaction material is passed through an ionizing device: the ions so formed are accelerated through an electrostatic or electromagnetic accelerator, and are ejected in space beyond the rocket.

The criteria for design of an ionic power plant depend on the intended use for the ship carrying the plant.

Generally, the known data will be: the mass of the ship, the mass of the reaction material, and the power output available from the power plant.

If the ship is required to reach the highest possible top speed with the available reaction mass without regard for the time involved, the motor should be designed to yield the highest possible jet speed. This stems directly from the "rocket equation":

$$V_f = V \times \ln \frac{M + Mr}{M}$$

where V is the final velocity attained by the rocket, Mr is the reaction mass, M the ship's "empty weight."

In this case it will be desirable at least in theory, to use ions of high $\frac{e}{m}$ ratio, namely light ions, such as hydrogen.

The characteristics of this mode of operation are: low acceleration, low values of jet flow, low power requirements:

As an example, assume a ship of the following characteristics:

Total Weight: 100 Tons
Reaction Mass Weight: 10 Tons
Power Plant Output: 10,000 HP

Assume H_2 is chosen as the reaction substance: a linear accelerator operating at 100 KV is used. The jet velocity will be 3,000 Km/sec. The acceleration turns out to be 0.000005g's.

At burnout, the ship will reach a velocity of 285 Km/sec.: it will employ a little over 180 years to reach this speed. During this time the ship will cover better than 500 billion miles (in gravity-less space). The flow will be 1.66 milligrams per second. The total need will be equivalent to 200 pounds of U238 at 100% efficiency.

In this case, the time lapse involved is undoubtedly excessive. A better criterion is the requirement to cover a given distance (in gravity-less space) in a given time for the minimum amount of power output, at a given expenditure of reaction mass. A distance d can be covered by accelerating to a given velocity, then coasting without power for a period of time, and finally decelerating back to rest: or it can be covered by constantly accelerating for half the distance, and subsequently decelerating for the other half. It turns out that, for a ship of low mass ratio, the first alternative is slightly better, if the flight parameters are properly chosen: the second method is, however, almost near optimum.

In our spaceship example, if a distance of 50 million miles must be covered in 30 days (at the specified mass ratio of 1.09), the power requirement is around 3 million HP. If the same distance need be covered in five (5) months, the power can be reduced at 24,000 HP.

At higher mass ratios, a proportional reduction in the power requirements can be secured.

We conclude that, at least in theory, an ion rocket which must reach high speeds, or which must deliver low acceleration for prolonged periods of time should have these characteristics: Reaction substance as light as possible, or with high $\frac{e}{m}$ ratio, high jet velocities and high specific power output.

If the ship's specifications call for high accelerations, sustained for relatively short times, (such as may be required to leave the Earth's gravitational field, or for certain military vehicles), then the jet velocity should be reduced, and the flow correspondingly increased, or enormous power outputs are required. For any reasonable power, the flow must be increased to such an extent that completely impractical operations result.

In our previous example of a 100-ton ship, equipped with a 10,000 HP power plant, an acceleration of 2g's calls for a jet velocity of only 4 meters/second. The corresponding flow is 500 tons/second: only 20 milliseconds are available for acceleration. (By comparison, this amount of power, applied externally, could lift the ship at a constant speed of 25 feet per second, another demonstration of the basic power inefficiency of the rocket propulsion mechanism.) Thus, the ionic rocket is definitely not a high-g device.

The ionic rocket can yield very high specific impulse; it offers in principle high performance operation at low mass ratios.

Full utilization of these advantages requires very high power outputs, and thus necessitates machinery of very high specific power, of the order of ten to fifty horsepower per pound, at high efficiencies. If such high powers are not available, we must resign ourselves to low accelerations and longer times of flight, still retaining the advantage of low mass ratios.

It is worthy of note that at high powers, efficiency is necessary to keep the heat generation down. In one of the previous examples, a power output of 3 million HP at 50% efficiency would generate sufficient heat to melt all the metal in the spaceship in less than a minute, and even at efficiencies of 95%, a good heat dissipating mechanism would be needed to insure reasonable temperatures.

Machinery such as this is completely beyond our state-of-the-art today. Thus the high-g, lightweight, high performance spaceship is still very much in the future: its realization may well require a radically new concept.★

SPACE AND SOCIETY

The relationship between astronautics and society, with emphasis on economics, has been dramatically underscored by plans for launching the IGY satellites.

Scientific achievements have, in the words of Wernher von Braun, now placed us on the threshold of the "golden technological age." He has even referred to the previous periods in civilization's advance as "bondage." Regardless of philosophy, the new scientific advances offer large fields of speculation for the economist.

In fact, von Braun says the *technological revolution* has brought about an entirely new set of unprecedented problems for the organization of human existence on this planet. Most of today's political problems are a direct consequence of this technological revolution. Capitalism, Socialism and Communism were unknown words before the invention of the steam engine. So were terms such as trade unions, raw material bases, transoceanic supply lines, and oil concessions.

"One of the most crucial problems of our times lies in the fact that the very nature of technology is dynamic, while the forms of political law and order which mankind needs for a peaceful co-existence are fundamentally static," von Braun says.

The contradistinction between the static forms of political order and rapidly changing technological conditions is likely in the future as it has in the past, to create a continuous source of conflict. Every major invention changes the basis of human existence far more profoundly than a treaty between nations or statesmen.

The technological revolution knows no national boundaries. Its smokestacks, roads, railroads, power lines and industrial cities can be found on both sides of the Iron Curtain, in America and Europe, the cradle of modern industry, as well as in historically agricultural Russia and China.

It has spread like wildfire to South America and Australia and is establishing ever firmer footholds in the darkest parts of Africa. "Even spiritual India," says von Braun, "where since time immemorial men had held that the only road to human happiness was abstention from worldly ambitions, goods and riches, is now competing with the rest of the world in the construction of hydro-electric plants and the operation of transcontinental air lines."

Although the impact of astronautics on society and our economy has been felt, if economic barometers can be projected to any degree, the advances which have been made to date have been merely small, hesitant movements in preparation for the steps which will inevitably come later.

If energy controlled by man is the first factor in his steady advance, communications is the second. Mass communication has been a dream of every progressive leader in history.

Space satellites will teach us how to achieve mass communication. The increasing demand for energy will, of course, not be truly resolved until atomic energy complements other power. To be properly effective, energy must be plentiful and within the reach of the population served. This goal will be realized shortly. The satellites will speed this up. This is particularly true in radio and television.

The radio-television industry can foresee a universal series of networks. In the United States the feasibility of this has been demonstrated. European TV is equally obvious, based on the continental performance during the winter Olympics last year. Universal telephonic facilities can be projected just as easily as TV and radio. Dial an associate in Tokyo . . .

The family farm is no longer a sound economic entity. Technological advances and the scientific advances in the utilization of chemicals have doomed the barefoot farm boy with his mongrel pup and his fishing pole. Agricultural corporations with agronomists, auditors, mechanics, packers, merchandisers and salesmen make up the personnel on today's farm. Hence the economists use the term food and fiber industry.

Take the food and fiber industry for example. Proper weather charting by space satellites will bring on a new era, enable further development of the industry, creating the opportunity for greater research across the board.

To the economist, the extended development of mass communications portends great, new markets for goods and services. The efforts to achieve a measure of productivity in keeping with the demands will tax the ingenuity of the industrial engineers. But there can be no doubt of the ability of these men to cope with the problem. Automation will play an important role, as it does even now.

The need for the increased productivity will also show up the need for additional financing. It always does. Thus, the monetary structure must be considered. During periods of controlled inflation, the prosperous periods of expansion and development, investors are eager to support new developments and risk capital is fairly easy to come by. The nation is in just such a period, and indications are it will continue in this phase for a long time.

There can be no doubt that the studies produced during the IGY will, in all phases of the social structure, have a direct effect on the economic structure. Corporations seeking diversification, and expansion will find new lines to enter. Banking establishments, too, will want to support some of these productive enterprises. As a result the basic diversification of industry will probably be accelerated.

If all of these ideas can see any measure of fulfillment, then the economist will revise his thinking on a national scale and bring it up to a truly international scale.

For man will have to concern himself with the gross universal product. The fact that the IGY satellites now are estimated to cost $57 million, much more expensive than originally planned, is insignificant. This is the most promising investment man has undertaken.

In the words of von Braun:

"It is difficult to think of a field of human endeavor that will not be involved in Man's Greatest Venture. Thus it is only natural that space flight has moved to the forefront of scientific research.

"It is the ultimate objective of our great Technological Revolution to free Man from the slavery of heavy physical labor, to elevate Mankind from its historical bondage to a race of masters, in whose service toils an army of mechanical and electrical slaves.

"This liberation through technology will enable Man to devote more time to think and to dream; it will raise all our civilizations to levels never before attained in human history. Space flight will free Man from his remaining chains, the chains of gravity which still tie him to this planet. It will open to him the gates of Heaven."

Air Force Studies Ion Power

By Henry T. Simmons

INGENIOUS NEW IDEAS in the field of ion propulsion are spurring lively government and industrial interest in the charged particle as a posible key to the next big rocket power breakthrough.

Probably the most active government agency in the ion propulsion picture right now is the Air Force Office of Scientific Research, which carries out highly advanced study projects for the Air Research and Development Command. At least three AFOSR contractors are presently working on various phases of ion propulsion:

Giannini Research Corp., Costa Mesa, Calif., ion plasma jets; Avco Manufacturing Co., Research Division, Everett, Mass., means of magnetic acceleration of gases; North American Aviation, Inc., Los Angeles, a feasibility study of ion propulsion.

In addition, several companies are investigating ion possibilities with their own funds. These include The Martin Co., Baltimore, and the newly-formed Astronautics Division of General Dynamics Corp., located in San Diego.

It is doubtful whether the dollar value of present ion propulsion research exceeds $1 million a year, but it is clear that keen interest already shown in the field presages a general expansion of such activity.

This growing interest is based on a general conviction among scientists and engineers that liquid propellant rocket combustion engines can be increased in specific impulse by only about 50% over present levels, or to a figure of about 375 pounds of thrust per pound of propellant per second. Ion propulsion specific impulse figures in the tens of thousands.

Ion propulsion has some major drawbacks, to be sure. One is the fact that any ion drive requires enormous amounts of electrical power to vaporize, ionize and accelerate the particles to high velocities. An even more important disadvantage is the very small amount of thrust developed by ion systems in relation to the mass propelled. It is so low, in fact, that no ion propulsion system so far suggested can possibly lift a vehicle from the Earth without aid from combustion rockets.

A fascinating discussion of the problems and potentialities of ion propulsion was presented to the recent spring meeting of the American Rocket Society in Washington by Martin I. Willinski, an engineer employed by the Preliminary Design Section of North American's Rocketdyne Division at Canoga Park, Calif. Willinski, together with Mrs. Elsie Orr and other North American technical personnel worked up the idea of "Project Snooper" in their spare time.

Snooper is an unmanned, ion-propelled contraption which could reach the Moon, Mars or other planets, circle them at close range, and transmit its findings back to Earth by means of television and radio. The vehicle would have a total weight of 3,300 pounds, including an allocation of 1,150 pounds for an unshielded atomic reactor, heat exchanger, turbo-generator and electrical system, 280 pounds for a heat radiator, 220 pounds for propellant, 150 pounds for structure, and 1,500 pounds for payload, including guidance.

Snooper's propulsion system would consist of two ion motors which would accelerate charged particles of cesium vapor at a velocity of 657,000 fps, compared with conventional chemical combustion exhaust velocities of about 6,000 feet per second. But the system would be limited to a total thrust of about one-third of a pound, or about .0001 gravity. This would provide Snooper with an acceleration of about .04 inch per second.

Source of Snooper's power would be a fast or intermediate nuclear reactor which could operate for a year or more before the slow accumulation of poisonous isotopes choked off the reaction. The reactor would have a total thermal output of about 1,000 kilowatts, sufficient to produce about 147 kw of electrical power. Sodium would be used as a reactor coolant, giving up its heat to mercury through a heat exchanger. The mercury would drive the turbo-generator and then flow through a second condenser-heat exchanger where it would give up its heat to a sodium loop which would circulate through the huge bat-wing radiators necessary to reject unwanted heat from the cycle. These radiators would be folded around the vehicle during the boosted portion of the flight, and unfold when the ion system would commence operation.

Cesium was chosen as the propellant for a variety of reasons, although the other alkali metals—lithium, sodium, potassium and rubidium—were also considered. Cesium has the highest ionization potential of all the alkalis, the lowest melting, boiling and vaporization points of the alkali family, and the highest density.

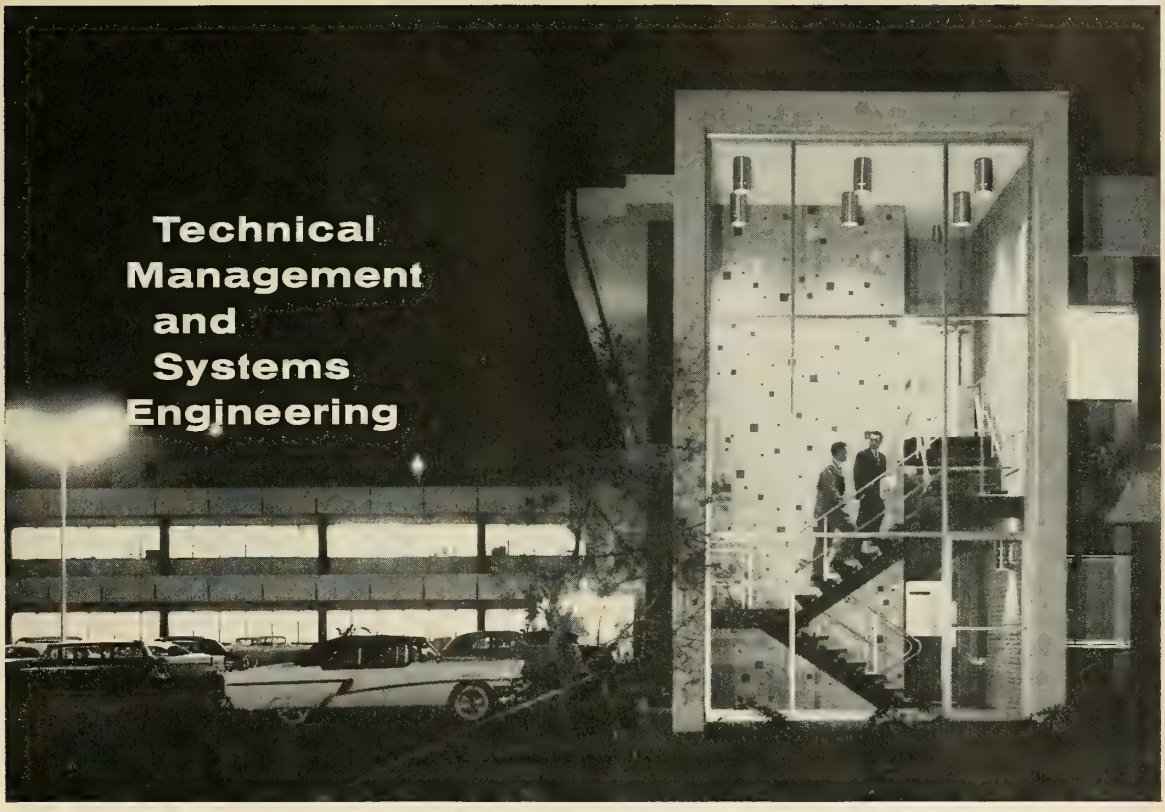
In the Willinski-Orr vehicle, the cesium would be contained in a tank heated by an electric blanket to about 100°F. to hold it in a molten state. An automatically controlled metal expellant bag within the tank would pressurize the vessel and force the cesium into an atomizer which would vaporize the metal at a temperature of approximately 1,500°F.

The vapor would then flow through a sintered steel distributor and then impinge upon incandescent tungsten surfaces formed into a series of ionizing grids. After a stay of only a few microseconds on the grid, essentially all the cesium atoms would lose an electron and become ions.

At this point, the ions would be accelerated across a three-centimeter gap to a velocity of 657,000 fps by a direct current potential of 27,500 volts. The cathode grid would consist of a honeycomb cross-section to assure a uniform electrostatic field in a radial direction. The authors note that this motor is based on a system proposed by Dr. Ernst Stuhlinger, research scientist for the Army Ballistic Missile Agency, Huntsville, Ala. They also make use of a Stuhlinger technique for simultaneous ejection of the electrons along with the ions by means of an emitting system located downstream of the cathode grid. The electrons thus mix with the ions at a point which does not interfere with the efficiency of the reaction and no excessive negative potential is allowed to accumulate in the vehicle.

The Willinski-Orr proposal is not related to North American's contract to study ion propulsion for AFOSR. So far as is known, there is no working model of an ion propulsion system now in existence. But the enormous potential of ion propulsion means that such hardware will be placed under contract before much more time elapses.

As to the task of getting such a vehicle into an orbit around the Earth, Maj. Gen. Bernard Schriever, chief of ARDC's ballistic missile program, has all but promised that the ICBM will be available for scientific research after its development as a weapon. He said in February that 90% of the unmanned space exploration projects now visualized "could be undertaken with propulsive, guidance and structural techniques presently under development in the Air Force ballistic missile program." ★



In systems engineering work, it is necessary to bring together a team that includes scientists and engineers of a wide range of technical specialties. In major weapons-systems projects, such teams will include hundreds of scientists and engineers.

But the assembly of a large group of scientists and engineers, no matter how capable they may be individually, does not of itself ensure good systems-engineering performance. The caliber of the project management has a major effect upon its technical accomplishment. It is not easy to coordinate the activities of large numbers of scientists and engineers so as not to stifle their creativeness on the one hand, nor to permit the various development sub-efforts to head toward mutually incompatible objectives on the other.

Of primary importance for good systems management is the philosophy underlying the selection of the supervisory personnel. The head of a technical activity should, first of all, be a competent scientist or engineer. A common mistake — nearly always fatal in systems work — is to fill such positions by non-technical men who have been trained only in management techniques. In the highly complex activities of major systems work, what is required is *technical management*, and of the two words, the word *technical* must never be overlooked.

In the selection of scientists and engineers for technical management, it is essential that the men chosen be broad in their training and approach. Each principal department head, for example, must have a good basic understanding of the technical facts of life of the other departments. When these people get together they need to speak a common language and understand each other's fields, so that proper decisions can be made on the many interrelated problems that come up. The higher the organizational responsibility of a technical manager, the more important this factor becomes.

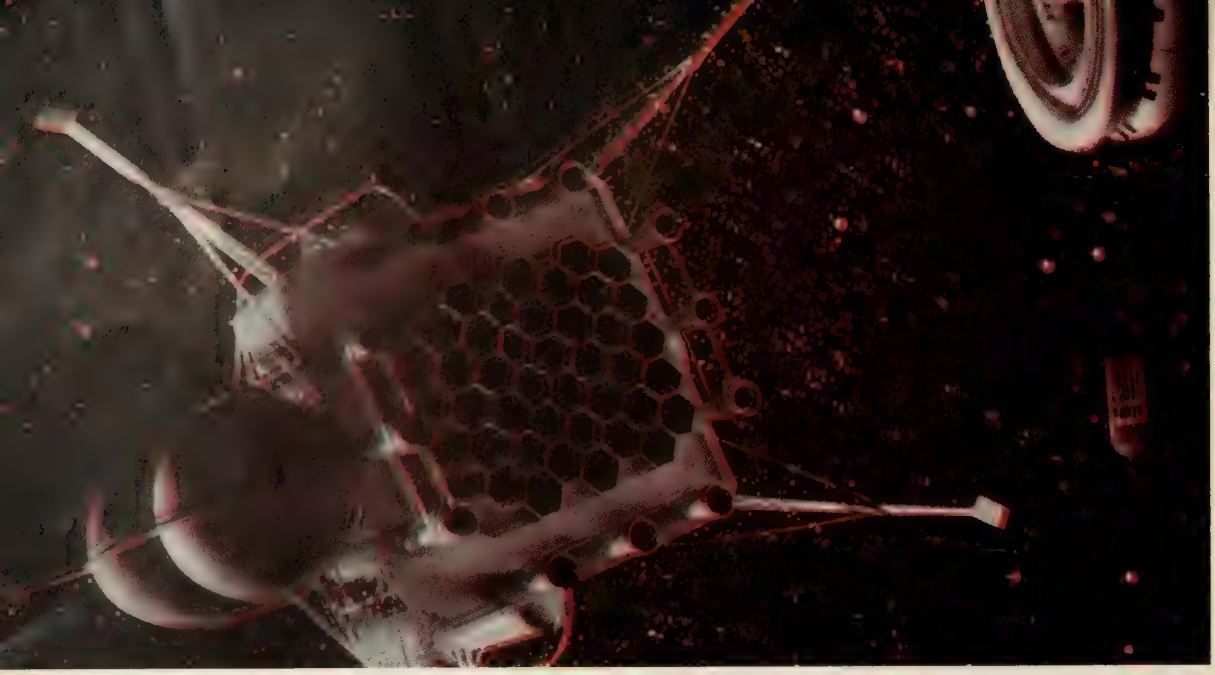
The Ramo-Wooldridge Corporation is engaged almost entirely in systems work. Because of this, the company has assigned to scientists and engineers more dominant roles in the management and control of the business than is customary or necessary in most industrial organizations.

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Use of space stations or space platforms for reconnaissance purposes and possibly for military use has been proposed by many experts.

Open Sky Plan in the Atomic Age

by Dr. Edgar A. Parsons
Member, Planning Staff
Federal Civil Defense Administration

WITHIN A DECADE the major military powers will be able to activate open-sky inspection plans through use of satellite vehicles. These will contain military reconnaissance gear, camera scanning equipment, television and telemetering instrumentation.

Use of reconnaissance satellites will be an inevitable outgrowth of the IGY satellite effort. Now is the time to consider the forthcoming sky sweep from all angles.

Meanwhile the big-two are attempting to reach agreement on mutual arms inspection. Major recent events include:

—The Soviet Union's statement that it will accept a limited "open skies" inspection plan, including creation of ground inspection posts.

—The U.S. counter-offer of a three-way surveillance over Alaska, Northern Canada and Northern Siberia.

If the statesmen are groping for solutions, the scientists and engineers are already demonstrating their own solutions for the manufacture and delivery of appalling payloads in a matter of minutes to distant targets. Achievements here include:

—The United Kingdom exploded its first H-bomb May 16th.

—A new $100-million base which will serve as our first operational launching site for ICBM, and the training of launching crews has been opened at Camp Cooke, Calif.

—The tempo of firings at Patrick Air Force Base has increased.

In view of these developments, what can man do in the interim period until operation sky-sweep becomes a reality? What kind of inspection is possible meanwhile?

General Nathan Twining, USAF Chief of Staff, has summarized the danger to the U.S. of nuclear disarmament. In a statement cited by a Senate Committee on Reduction and Control of Armaments, he stated: "To give up our nuclear weapons, unless arms were truly banned, would mean victory for the Communists."

Inspection poses a tremendous problem: It is not technically feasible to detect hidden nuclear stockpiles or to accurately account for past production of nuclear weapons. Atomic bombs can be made peculiarly insensitive to instrumentation. One could be almost on top of such a bomb and not know it.

The difficulty of accounting for past production of nuclear weapons is attributed in part to three factors: (1) the relatively inaccurate character of the assay for uranium isotopic content, (2) the tremendous extent of the atomic energy plants, (3) undetectable but legitimate losses within the process.

Dr. Manson Benedict, Chief of Operation Analysis of the Atomic Energy Commission, has speculated that "from one to five bombs per year could be produced from non-accountable material if one sought to divert material improperly."

Unreliable accounting of fissionable materials, together with relative ease of this interchangeability for either peaceful or military uses, are basic difficulties which must be overcome. In an unprecedented step to help overcome these difficulties, the U.S. Government, through the Disarmament Commission of the United Nations, recently invited

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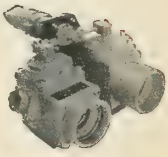
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"the scientists and officials of any nation in the world, if they believe they have a method which can completely account for past and present production of fissionable materials and to insure against improper diversion of nuclear weapons, to come forward and advance for consideration such method."

Aerial Reconnaissance

With present equipment, one plane can photograph a 490-mile wide strip across the entire United States—a distance of 2700 miles—*in less than four hours.*

There is a great difference, however, between taking photographs and interpreting the results. While aerial reconnaissance is most effective in detecting large objects, it has definite limitations: the camera eye can be fooled, there is difficulty detecting small objects, and a camera cannot look through opaque surfaces.

Today's ICBM launching and testing sites are huge and complicated agglomerations of extremely bulky equipment. As soon as intercontinental ballistic missiles become available in operational numbers, launching sites will probably be "miniaturized" and dispersed throughout the country. This would make detection extremely difficult and destruction by long-range bombardment almost impossible.

It is assumed the sites will gradually be decreased to about the size of the launching pad. For some missiles, this might be only 10′ x 10′. The missile itself, as well as its launching pad, might well be below the surface of the ground, and maintained in a state of readiness by personnel housed in underground chambers. Sliding or folding doors with great resistance to blast, over-pressure, and radioactivity, would protect the missile from bombardment, as well as from chance detection by the camera.

Although the art of subterfuge and camouflage is clearly superior to the science of aerial photography detection, if the photogrammetrist knows precisely where to look, and is provided a series of detailed photographs, large scale activity would be detectable.

Need for Speed

It was reported last fall that an Army test vehicle traveled 3,300 miles. The missile allegedly soared to an altitude of 650 miles and terminated its flight in the South Atlantic. Continued high level of progress is evident in the press statement last March by Maj. Gen. John B. Medaris, Commander of the Army Ballistic Missile Agency, that development of the Army's Jupiter is "on schedule or ahead of schedule in every respect" and will be "brought to a successful conclusion on time."

The essence of the problem is to control the military application of atomic weapons by control over the means of mass delivery.

The longer the period of time that elapses before international agreements are consummated, the greater the opportunity for deceit and subterfuge.

If the technologists and engineers produce operational missiles before the diplomats agree on an inspection procedure, no nation can be sure that the other nations will reveal the true extent of their respective arsenals. Without such certainty, of course, disarmament is not feasible, and the world must continue to live with the fear of surprise attack.

Much can be done to make the most of whatever time remains without waiting for international agreement.

We should:

(1)—*start now to train the ground inspectors and aerial technicians required to implement a reliable inspection system.*

The administrative problems can be solved now, and personnel can be trained to implement our inspection agreement without delay.

(2)—*institute a ground and aerial inspection system now with an ally.*

This would facilitate the training of ground and air inspectors and reemphasize to the world the seriousness with which the United States regards its mutual inspection proposals. Such an interchange would reveal the capabilities and limitations of ground and air inspection, and thus provide opportunity for refinement of techniques.

(3)—*negotiate for expansion of the existing military attache system.*

The U.S. and the USSR have for many years exchanged attaches, who are now customarily invited to witness certain military demonstrations. This attache exchange arrangement might serve as a nucleus for future ground inspection teams.

Initially, it would not be necessary to give these attaches permission to visit all the buildings of a particular installation. Through working level agreements, reinforced with concurrent high-level negotiations, it may be possible to facilitate mutual information exchange as an interim measure.

(4)—*institute an inspection system with a part of the USSR or a Soviet-satellite now.*

This recommendation would also facilitate the training of required inspection personnel. It would demonstrate, at first hand, the possibilities and limitations of the open skies proposal. This would provide first hand experience, without irrevocably committing the two parties.

(5)—*establish a working procedure with recipients of fissionable material to insure proper accountability and minimum danger of diversion to military use.*

Various technological arrangements will be required to insure that fissionable material will not be diverted for military purposes. To some extent agreements will provide the basis for a continued U.S. inspection and supervision over these fissionable materials; and these same arrangements might provide a basis for continued U.S.-USSR negotiations.

(6)—*pass the legislation required to establish open skies inspection now.*

Special amendment of the Atomic Energy Act was required to furnish atomic weapon information to our partners in NATO. According to Atomic Energy Commissioner Strauss, the Atomic Energy Act would have to be amended to permit foreign inspectors to examine atomic energy installations, facilities and stockpiles. If this evaluation is correct, the U.S. could not legally agree to a bona fide inspection system without new legislation. It is feasible, of course, to provide a legal basis for such inspection through the treaty device but even here ratification would require approval of the Senate. Experience does not warrant optimism for the speedy passage of such a treaty.

A comprehensive international inspection system might well be regarded as diluting the war making power of the Congress. An inspection system might also impinge upon the President's Constitutional powers as Commander in Chief. The precise Constitutional implications, of course, will not be clear until inspection agreements have been drafted. Nevertheless, the American public should be alerted now to the Constitutional implications.

Prospects for a speedy legal solution are dim indeed if inspection and disarmament procedures require amendment of the Constitution. The Second Amendment to our Constitution suggests some of the legal obstructions, which may not be insurmountable, but will undoubtedly be time consuming: "A well regulated Militia, being necessary to the security of a free State, the right of the people to keep and bear Arms, shall not be infringed." The possibility of this obstacle cropping up should be faced now and overcome.★

Note: The opinions in this article are those of the author and do not reflect an official evaluation of any agency or government.



Rocket Engineering

By Alfred J. Zaehringer

NEW FUEL: DIMETHYL SULFIDE. West Coast researchers have found the compound valuable in controlling the combustion of monopropellant ethylene oxide. Crown Zellerbach Corp., Camas, Washington, now offers the low cost fuel, of 99% purity, in tank car lots.

ETHYL CORPORATION has patented a new process (US 2,787,626) for producing aluminum triethyl (AT). AT ignites spontaneously in air and is being tested by government and industry as an igniter and fuel for ram jets and turbojets. US Industrial Chemicals has recently made this material available in pilot plant quantities.

USE OF LITHIUM and its compounds as a missile fuel is still small. Total lithium production in 1956 was about 50 million lbs. Estimates put nondefense lithium at over 11 million lbs. The difference is now going to AEC in their nuclear program and in government stockpiles. However, Purdue University chemists now see a promising future for lithium hydrides in conjunction with boron hydrides in the preparation of exotic boron fuels.

COMPOSITE LIQUID PROPELLANTS—premixed solutions of fuel and oxidizer—are now being tested in rocket runs here in the U.S. Biggest problem seems to be stability and shelf life. Getting performances of 250-300 sec is now "routine" for many of the new high-energy liquid combinations but they start to fall apart in stability over the 225 sec mark.

INDICATIONS OF PHILLIPS PETROLEUM potential in the solid propellant field can be gleaned from these annual production figures from their Chemical Division: 235 million lbs. of carbon black, 715,891 tons fertilizer, and 56,121 long tons of synthetic rubber. The Rocket Division uses unknown quantities of all these materials for producing ammonium nitrate-type solids.

MORE ON FREE RADICALS: University of California scientists have mapped the infrared spectrum of typical atoms. The potential rocket fuels have already been studied in the ultraviolet and visible regions by others.

SEVERAL MATERIALS are compatible with gaseous fluorine at atmospheric pressure but, says NACA, only Teflon and aluminum oxide can stand up at pressures of 1,500 psig.

FURALINE III is the furfuryl alcohol base fuel used with 98% nitric acid for the SEPR 481 rocket engine. The three-chambered 481 is used on the SO.9000 *Trident* I aircraft. Total nominal thrust is about 9,900 lbs. Maximum sea level thrust is 10,500 lbs. and nearly 11,500 at an altitude of 40,000 ft. The *Trident* II is to be equipped with an improved model, the SEPR 631.

MORE NITRIC ACID ON THE WAY: Allied Chemical & Dye Corp. is adding a new nitric acid unit to its Newell, Pa. facility which will double present capacity.

SCALING DOWN a solid propellant rocket motor presents some unusual difficulties. In miniature motors of a few ounces of thrust, standard design techniques are not wholly adequate because of excessive heat losses to the relatively more massive chamber walls. NACA's Langley facility did manage to design a small rocket to deliver 3 ounces of thrust for 2 seconds. Propellant weight was slightly over 1 gram, total loaded weight was 18.5 grams. It is interesting to note that the Cordite SU/K propellant produced an I_{sp} of 145 sec at a chamber pressure of 353 psia.



Ion Propulsion and Why . . .

A Comparison of Space Ship Propulsion Systems

by Ernst Stuhlinger

Army Ballistic Missile Agency
Huntsville, Alabama

A SPACE VEHICLE, like any vehicle in any system of reference, can be accelerated in a given direction only by accelerating some mass in the opposite direction by a force which acts between vehicle and mass. The resulting movements of the vehicle and the reaction mass are governed by the law of conservation of momentum.

The main requirement of a propulsion system can be described thus: the product m.v should be as large as possible, where m is the total propellant mass, and v the exhaust velocity. An additional requirement applying to a space ship is that the ratio of the total initial mass of the vehicle to the payload mass should be as small as possible to make the trip economical.

The total mass includes the structural mass, the propellant mass, the mass of the thrust chamber, the payload mass, and, where applicable, the mass of the power plant.

A number of different propulsion systems have been suggested for space vehicles. Four of them will be considered here.

In the first system, the propellants are accelerated by heat energy from chemical reactions.

In the second, the propellants are accelerated by heat energy from a separate power source like a nuclear reactor, an electric arc, or the sun.

In the third, the propellants are ionized and accelerated by electric fields.

In the fourth, photons are emitted. They create thrust by virtue of the momentum which they impart to the vehicle when they are emitted from a radiation source.

Chemical Systems

Chemical rocket engines are the best known since they have been used successfully in many earth-bound rockets. They have the great advantage of combining the propellant mass and the power for its expulsion in the fuel-oxidizer system. No separate power source is necessary. Their disadvantage is that the exhaust velocity v, a function of the combustion temperature, is limited to relatively low values. The total propellant mass m must therefore be high. The combustion temperature is determined by the energy of combustion, by dissociation effects, and by the temperature resistivity of structural materials. Modern rocket engines have exhaust velocities of 2500 to 3000 meters per second. It does not appear likely at present that chemical rocket engines with much greater exhaust velocities will be developed in the near future for space-going vehicles.

Several studies have been published dealing with chemical propulsion systems for space vehicles. The most detailed of these, "The Mars Project" by W. von Braun,[1] provides the characteristic data of a chemical propulsion system capable of taking a space ship to Mars and back.

This system uses hydrazine and nitric acid as propellants with an exhaust velocity of about 2800 meters per second. The highest acceleration attained during the trip is of the order of one G.

The ratio of take-off weight to final weight after consumption of all fuel, is about 25 to 1. Burning time is 16 minutes. Travel time from earth to Mars would be 260 days.

Gas-Heating Systems

The next category is characterized by three different designs. The characteristic data of the first one, a propulsion system using a uranium reactor which heats liquid ammonia, can be derived from reactor design and operation data that were published recently.[2]

The second is a solar energy ship proposed by K. Ehricke.[3] The third is based on the high-intensity electric arc, a gas-heating method which may find application in wind tunnel systems.

In all three proposals, the energy source is separate from the propellant mass. This separation introduces a weight penalty as compared to the

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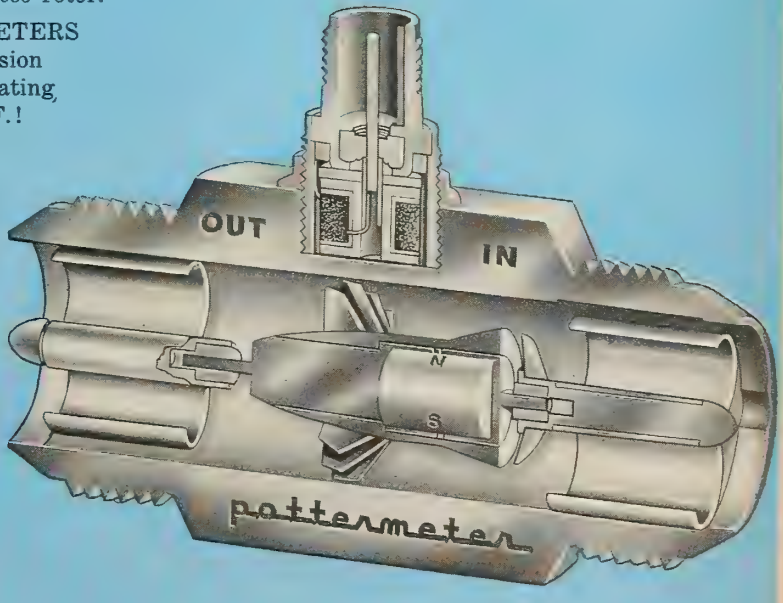
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chemical propulsion system which can only be compensated by higher exhaust.

The nuclear reactor system, in which ammonia is pumped through graphite tubes inside the reactor, provides an exhaust velocity of about 4000 meters per second. This value is limited by the heat resistivity of existing structural materials.

Using pure hydrogen, exhaust velocities of the order of 6000 meters per second can be expected. It seems that the reactor-heating method becomes superior to chemical systems only when space ships are considered whose take-off weights are greater than a few hundred tons.

The solar-powered ship designed by K. Ehricke uses two large reflectors which are formed by inflated balloons of Mylar polyester; one half of each balloon is coated with aluminum. In the focal area of each reflector there is a boiler in which liquid hydrogen is vaporized and heated to a temperature of 850°C. Blowing out through a nozzle, the hydrogen jet develops a thrust of about 160 pounds. Its exhaust velocity is of the order of 4500 meters per second. The acceleration of the ship is about 1/100 of one G.

Since the energy-producing system in this case is very light, the solar-powered hydrogen ship may well be superior, weight-wise, to a chemically propelled ship on shorter interplanetary trips. Its life would be limited, though, by the action of meteors which puncture the balloons. Even though the deflation would be very slow, one could not expect an operating lifetime of more than a few weeks.

The technique of heating a gas, or rather a plasma consisting of atoms, molecules, and ions, by a high-intensity electric arc, has been developed mainly by Finkelnburg, Maecker, and Peters[4], and by Giannini.[5] Exhaust velocities of about 6000 meters per second have been obtained.

The electric power needed to operate the high-intensity arc could be generated with a nuclear reactor driving a turbo-generator. Considering the fact that exhaust velocities of the same order can be obtained by direct heating of hydrogen in an atomic reactor, it seems doubtful whether the complicated mechanism of turbo-generator and electric arc would pay off.

Direct generation of electric power by means of radioactive isotopes has been considered by H. Kaeppeler.[6] Although this method of providing electric power would be very straightforward, it is likely that the production and handling of such large amounts of radioactive isotopes as needed would present insurmountable difficulties.

The heat generated within the radioactive substance and the structural elements of the battery would amount to at least 20 or 30 per cent of the electrical power output. Dissipation of this heat would be a severe problem.

Electric Systems

Electric propulsion systems for space vehicles were proposed as early as 1923 by H. Oberth.[7] A more detailed design and performance study of an electrically propelled space ship has been worked out recently.[8] The payload chosen for that design is 150 tons.

The primary power source is a uranium reactor which generates heat for steam production. Electric power is produced by a turbo-generator with radiation cooler. The propellant material is rubidium or cesium; these metals ionize easily and with an efficiency of almost 100 per cent, if they are vaporized and brought in contact with hot platinum surfaces. The ensuing ions and electrons are then subjected to electrical fields which accelerate them to high exhaust velocities.

The power contained in the jet increases with the square of the exhaust velocity; the total mass of the power plant, including cooler, increases at nearly the same rate. The thrust, however, increases only with the first power of the exhaust velocity. This fact is the reason why the exhaust velocity of the ions should not be too high.

A detailed investigation of a representative design resulted in an optimum ion exhaust velocity of about 80,000 to 100,000 meters per second, corresponding to an accelerating voltage of about 5000 volts. A higher or lower accelerating voltage would mean larger total mass of the ship for the same payload.

The ion thrust chambers as required for an electric propulsion system can be operated only when the space charge effects connected with charged particle beams are successfully eliminated. Neutralization of the space charge as soon as the ions have left the thrust chambers can be achieved by mixing the ions with the electrons from the electron thrust chambers.

Actually, the thrust contributed by the electrons is very small because of their small mass. However, they must be expelled from the ship anyway to keep the ship electrically neutral.

A representative space ship with an electric propulsion system, capable of carrying a payload of 150 tons to Mars and back, would have a total take-off mass of 730 tons, a propellant mass of 365 tons, an accelerating voltage of 5000 volts, a total electric power production of 23,000 kilowatts, a thrust of 50 kilograms, and an acceleration of a little less than 10^{-4} of one G.

The propulsion system would work during the entire trip, partly accelerating, and partly decelerating the vehicle. Total travel time from earth to Mars would be about 400 days.

Photonic System

The common feature of the three previous kinds of propulsion systems is that they could be built with techniques as we know them today. This is not true for the fourth kind of propulsion system, the photonic rocket.

A photonic propulsion system emits an unidirectional beam of photons. Their momentum is E/c, the quantum energy divided by the light velocity. The theory of photonic propulsion systems is based on the assumption that the photons can be created by direct and controlled conversion of matter into radiation energy according to the fundamental Einstein equation $E = m c^2$, a conversion which can be observed in nuclear processes, for example in the annihilation of an electron and a positron to form a pair of gamma quanta, but which is not yet known to exist on a technical scale.

Provided that the entire mass of the propellant could be converted into energy according to Einstein's equation, the energy content of matter is 10^{10} times greater than the chemical energy content of conventional propellants, referred to the same mass.

For a proper functioning of the photonic propulsion system, the further assumption must be made that photons of all the wavelengths generated in the conversion process can be reflected and collimated to form an almost parallel bundle. The collimating mirror must have a reflecting power of the order of 0.99999999.

If the photons are generated within a container, its walls must have a transmissivity of the same order. With lower reflectivities and transmissivities, the mirrors and walls would absorb such great amounts of radiative energy that they would vaporize immediately.

Although these requirements are still completely out of the range of present technical feasibility, it is most interesting to study the principal features of a photonic propulsion system. A number of very thorough studies on the mechanics of photonic propulsion have been published by E. Saenger.[9]

Assuming that the direct and controlled conversion of matter into radiative energy is feasible on a technical scale and that the ensuing photons can be collimated without noticeable absorption by lenses or mirrors, the relativistic formulae for mass consumption, thrust, velocity, mass ratios, and

flight times of photonic space ships can be developed. It must be admitted that the photonic propulsion system opens horizons to space travel which are entirely out of reach for "classical" designs of space ships. Since the exhaust velocity of the photons is equal to 300,000 kilometers per second, an appreciable thrust could be obtained even with an extremely low mass consumption. After a sufficiently long time of operation, the ship would approach light velocity.

The relativistic dilatation of its own time, as experienced by the space travelers, would then become noticeable. Even trips to remote galaxies could then be made within a few years as counted by the crew of the ship. The following table shows the time interval $\triangle t$, the acceleration b, and the total elapsed time t as measured from the earth and on the ship.[10]

Table I. Relativistic transformation formulae.

Earth system	Ship system
Time interval	
$\triangle t = \triangle t_0 / \sqrt{1 - v^2/c^2}$	$\triangle t_0$
Acceleration	
$b = b_0 (1 - v^2/c^2)^{3/2}$	b_0
Elapsed time	
$t = c/2b_0 (e^{b_0/c\, t_0} - e^{-b_0/c\, t_0})$	t_0

These formulae show that the relativistic effects are the same for positive and negative velocities, and for positive and negative accelerations. In particular, if a crew of space travellers left the earth on an accelerating ship and returned after some time on a decelerating ship, the crew members would find that during their absence everything on earth has aged more than they have themselves.

The difference between the time elapsed for the earth and the time elapsed for the crew is determined by the formula in the last line of the above table. Some pertinent figures of space trips made with photonic propulsion systems are listed in Table II.

While the propellant mass needed for a voyage as far as the planets would be negligible, the necessary mass ratio of a photonic ship capable of a round trip through the universe would require, for an empty mass of about 600 tons, a propellant mass equal to that of our whole earth

Even though a photonic space ship cannot be achieved with technologies which may be at our command within the forseeable future photonic propulsion studies are most interesting as speculations because they give an idea of where the limits are set in principle by the basic laws of physics as we know them today.

It seems very obvious, though, that the two main problems of the photonic propulsion principle, the conversion of matter into radiative energy and the extremely high reflectivity of surfaces, will not be solved by engineering effort alone. Both problems are of a very fundamental nature. If they are solvable at all, their solution should be expected only as an achievement of basic scientific research.

Table III shows a few characteristic figures relevant to the four groups of propulsion systems considered in this paper. It is very likely that the first trip to another planet will be made with a chemically propelled ship, simply because its techniques are well developed.

Electrically propelled ships would be more economical from a weight standpoint, but they require a longer development time. Preference should always be given to that type of propulsion system which gives the greatest assurance for the crew's safe return.★

TABLE II

Characteristic Data of Photon Space Ship *

Trip	Mass Ratio	Ship Time	Earth Time	Distance
Half around earth	1.00007	47 min	47 min	2×10^4 km
Moon	1.0003	3.5 h	3.5 h	4×10^5
Planets	1.006	2 d	2 d	10^8
d Centauri	20	3.6 y	6 y	4×10^{13}
Center of galaxy	10^4	20 y	6×10^4y	2.8×10^{17}
Andromeda nebula	10^{11}	26 y	2.5×10^6y	7×10^{18}
Round trip thru the universe	10^{19}	42 y	4×10^9y	3.2×10^{22}

* A constant acceleration of 1 g to the midway point, and a subsequent deceleration of the same magnitude, was assumed for these trips. Mass ratio is the ratio of take-off mass to burn-out mass.

TABLE III

Comparison of Propulsion Systems

Propulsion System	Exhaust Velocity (m/sec)	Acceler. (G)	Power/Thrust (kw/kg)	Technical Feasibility
Chemical	3×10^3	1...8	15	Technology Proven
Nuclear or solar power plus light gas	$4..6 \times 10^3$	1...8	20..30	Technology Known in Principle
Nuclear power plus ions	1×10^5	10^{-4}	500	Technology Known in Principle
Photonic	3×10^8	1...2	3×10^6	Technology Unknown

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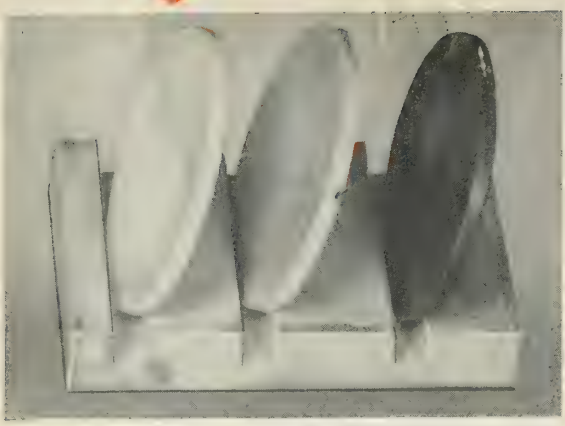
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SHORT-TIME	600°C
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The Ion Rocket

The Most Attractive Power Plant for Space Flight?

Dr. John E. Naugle

Convair Division

General Dynamics Corporation

THE ION ROCKET is a low thrust system which must be placed in a satellite orbit by a high thrust chemical or nuclear powered rocket. Once there, if the ion rocket has sufficient thrust it will slowly accelerate and escape from the earth's gravitational field. With the advent of the ICBM program and high-current ion ejectors the ion rocket moves from the realm of the imagination to a candidacy for advanced research and development.

A propulsion system with ultimate exhaust velocities in the neighborhood of 3×10^{10} cm/sec. is attractive but when this is combined with a system which allows these high exhaust velocities and the rate of mass flow both to be controlled, the possibility of interplanetary space travel moves from the realm of science fiction toward reality. The ion rocket works on an entirely different principle than a chemical rocket. Many people familiar with the operation and problems of the chemical rocket are not aware of the principles of the ion propulsion system. The purpose of this article is to present a highly simplified version of an ion rocket to illustrate the basic principles of the system.

An ion rocket operates by ejecting ions at high velocities. To accelerate the ions to these high velocities the propulsion system must exert a force on them and by Newton's third law an equal and opposite force will be exerted on the propulsion system, thereby accelerating the rocket ship.

The basic difference between an ion propulsion system and a chemical propulsion system lies in the difference between an ion and an ordinary molecule. An ion is a particle which carries a net charge. An atom or molecule is normally neutral. However, under certain conditions an electron can be added or removed. This charged molecule is an ion.

Neutral molecules are accelerated and acquire high velocities through collision with other neutral molecules whereas an ion can be accelerated in an electric field. In a gas composed of ordinary molecules the directions of motion of the molecules are completely random. A cloud of ions in the presence of an electric field will all move in the direction of the field.

An ion of net charge Q, mass m and in an electric field of magnetic E will have an acceleration a, given by:

$$a = \frac{EQ}{m} \qquad (1)$$

The acceleration of dust particles or any aggregate of molecules of mass m, and net charge Q will be given by equation (1), thus from a propulsion standpoint they should also be classified as ions and considered as possible propellants.

It is customary to refer to a beam of ions as a current of given amperage. If f ions of charge Q pass a certain point in one second the current I, in amperes will be:

$$I = fQ \qquad (2)$$

if Q is measured in coulombs.

The diagram illustrates the functions which must be performed to achieve propulsion in an ion rocket. The propellant is carried as neutral molecules. These are ejected into the ion source and ionized. Ions can be formed by radio frequency discharges, arc discharges and by other ions traveling at high velocities.

Electrons are removed from neutral molecules leaving them positively charged. The electrons may attach to another neutral molecule forming a negative heavy ion or remain as free electrons-light negative ions. An electric field can then be used to move the ions out of the source.

The positively charged ions move in the direction of the field and the negatively charged ions move in the opposite direction. After leaving the source, the ions pass into region B where their trajectories are curved to bring their direction of motion out the end of the rocket. This can be done



either by an electric or magnetic field in region B.

In region C strong electric fields are used to accelerate the ions to their exhaust velocities. This is a highly simplified concept but it serves to illustrate the basic principles. It is necessary to eject ions of both signs and in equal numbers, otherwise the rocket would acquire a net charge and attract and slow down ions it is trying to eject.

The thrust F, on the rocket is given by the relation:

$$F = fmu \qquad (3)$$

where f is the number of ions of mass m, and velocity u, ejected per second. If an ion of mass m, and charge Q is accelerated through a potential V, the kinetic energy which it acquires is given by:

$$\tfrac{1}{2}\, mu^2 = QV \qquad (4)$$

Using equations (2), (3) and (4), it is possible to express the thrust in terms of the important parameters as:

$$F = I\sqrt{2mV} \qquad (5)$$
$$\overline{Q}$$

Disregarding losses, the total power P put into the beam would be VI, the thrust per unit power would be:

$$\frac{F}{P} = \frac{I\sqrt{2mV}}{\overline{Q}} \cdot \frac{\sqrt{2m}}{\overline{VQ}} \qquad (6)$$
$$\overline{VI}$$

The thrust per unit mass is:

$$F' = \frac{I}{m}\sqrt{2mV} \cdot \frac{\sqrt{2V}}{\overline{Q}} \cdot \frac{I}{mQ} \qquad (7)$$

According to equation (6) a high thrust-to-power ratio is obtained with a propellant of high atomic weight and a low accelerating potential. A high thrust to mass ratio is obtained with a propellant of low atomic weight and high acceleration potential.

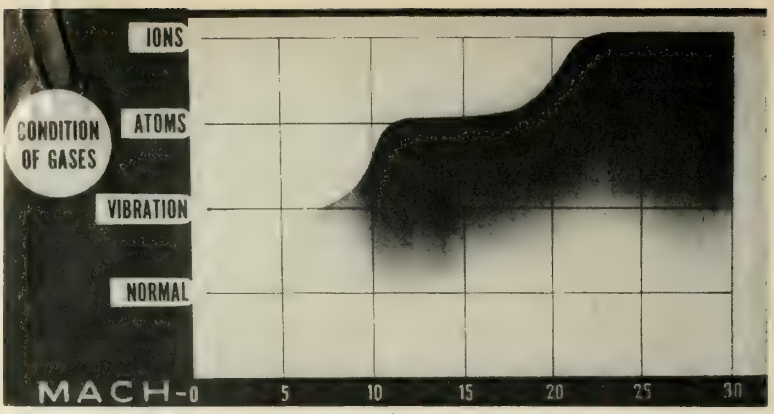


Chart showing dissociation of earth's atmosphere with increased speed. Ions from about Mach 20 and up could be used in electrical ion "ramjet."

In any actual design the weight of the power supply will have to be taken into account. This power supply may be electrical energy stored in batteries, a nuclear powered generator or a device to convert solar energy into electrical energy.

One of the very attractive features of the ion rocket is that both I and V can be easily controlled. This means that both the exhaust velocity and rate of propellant utilization can be varied.

The final design would incorporate the proper propellant and a programmed flight regime to make the rocket travel the maximum distance, in the shortest length of time with a minimum initial weight.

The major obstacle to be overcome to make the ion rocket feasible is the development of a high current ion source and a light and efficient power supply. The ionization process requires about 4 to 10 watts of power per ampere of ions.

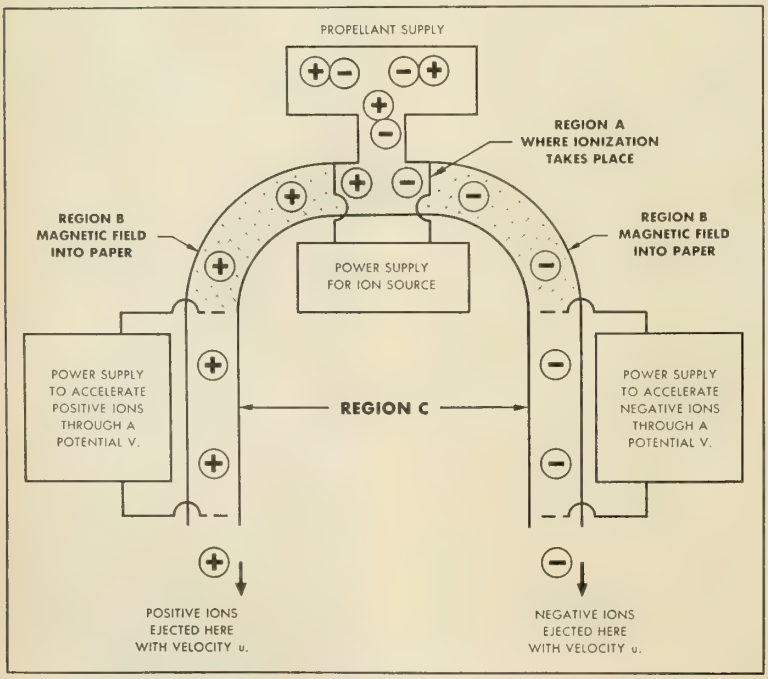
The actual process as used in the high current ion ejectors is still very inefficient. It actually required about 10 to 100 kilowatts of power to produce an ampere of ions. This power, however is independent of the exhaust velocity of the ion.

If the ions are accelerated through a sufficiently high voltage the power lost in ionization can be made small compared to the power in the beam or to the kinetic energy transferred to the rocket by this process.

The present "state of the art" for ion sources is best illustrated by the "High-Current Ion Injector" described by W. S. Lamb and E. J. Lofgren in Rev. Sci. Instr. 27, 907 (1956). This machine produces a 0.75 ampere beam of 100 kilovolt deutrons.

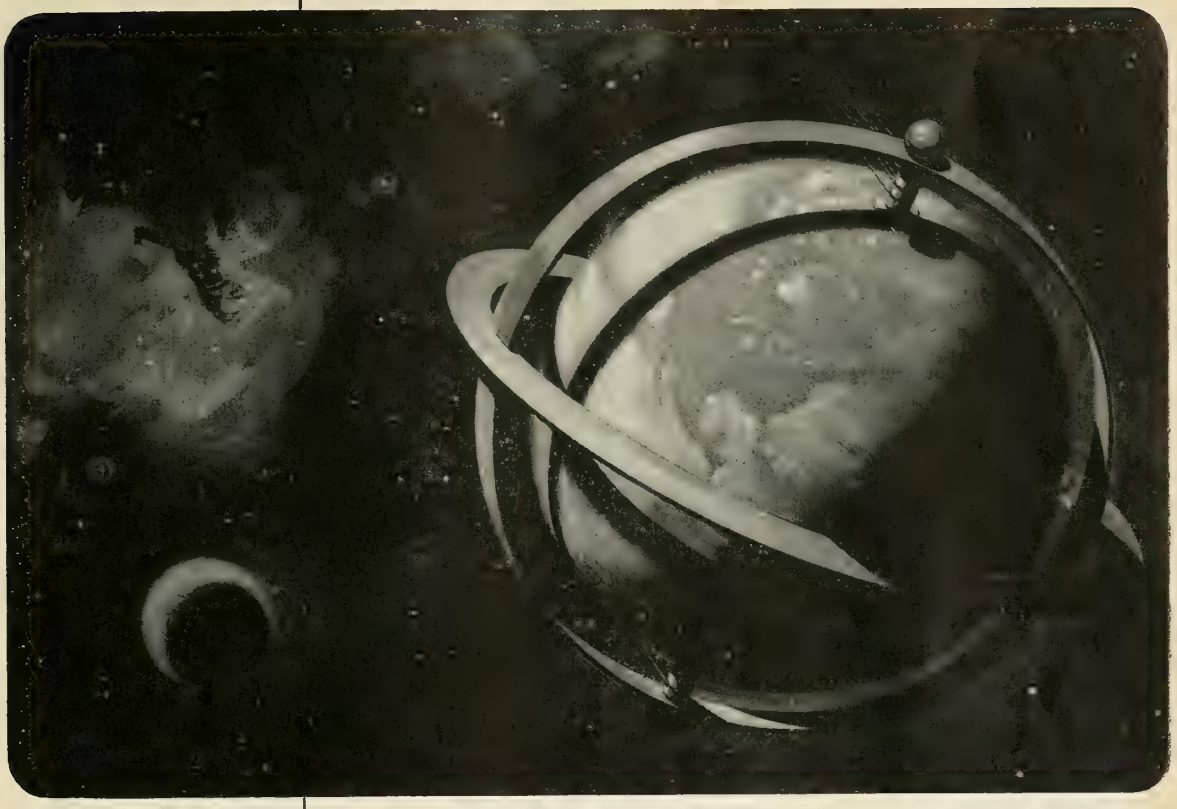
The total power into the machine is about 170 kilowatts, the power in the beam is about 75 kilowatts or about 44% of the electrical energy is converted into kinetic energy of the ions. The total thrust from this beam however, would be only about 5000 dynes or about 10^{-2} pounds. The exhaust velocity is 4.4×10^8 cm/sec.

In summary: the ion rocket is attractive because of the high and controllable exhaust velocities, the efficient conversion of electrical energy into kinetic energy and the overall control over the propulsion system. A major effort is required to produce ion sources of thousands of amperes, which ionize and accelerate the major fraction of the propellant carried aloft. A companion effort is required to produce an efficient light weight power supply.



Schematic diagram showing the basic layout of ion propulsion system.

IMPORTANT DEVELOPMENTS AT JPL



The Jet Propulsion Laboratory is a stable research and development center located to the north of Pasadena in the foothills of the San Gabriel mountains. Covering an area of 80 acres and employing 1550 people, it is close to attractive residential areas.

The Laboratory is staffed by the California Institute of Technology and develops its many projects in basic research under contract with the U. S. Gov't.

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For many years the Jet Propulsion Laboratory has pioneered in the design and development of highly accurate missile guidance systems, utilizing the most advanced types of gyroscopes, accelerometers and other precision electro-mechanical devices. These supply the reference information necessary to achieve the hitherto unattainable target accuracies sought today.

The eminent success of the early "Corporal" missile flights shortly after World War II firmly established the Laboratory as a leader in the field of missile guidance. These flights also initiated experiments involving both inertial and radio-command systems employing new concepts of radar communication. Because of this research and experimentation JPL has been able to add materially to the fund of knowledge available to designers of complex missile systems.

This development activity is supported by basic research in all phases of electronics, including microwaves and antennas, new circuit elements, communications and reliability in addition to other branches of science necessary to maintain a fully integrated missile research organization.

The Jet Propulsion Laboratory, therefore, provides many challenging opportunities to creative engineers wishing to actively apply their abilities to the vital technical problems that require immediate and future solution.

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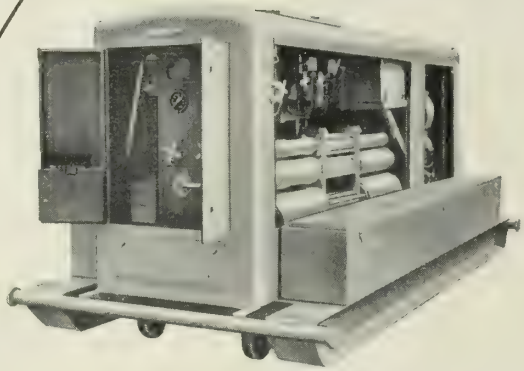
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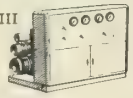
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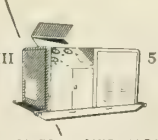
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MODEL LS-III — 40 TO 80 SCFM



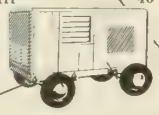
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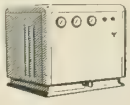
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engineering briefs

Robertshaw-Fulton Operates Test Facility

One of the nation's most complete facilities for testing controls and control systems used in missiles employing helium, nitrogen, oxygen or other gases as propellants or pressurization agents is now in operation at Aeronautical Division, Robertshaw-Fulton Controls Co.

The helium test equipment is capable of simulating internal environmental conditions encountered by aircraft and missiles.

According to Robert L. Wehrli, vice president and general manager of the division, the facility will be used principally for testing the company's line of aircraft and missile controls. In addition, testing assignments for outside companies and military agencies will be conducted on a contract basis.

The helium test facility consists of five 2-cu. ft. cylinders manifolded together and capable of storage pressures up to 6,000 psig, 50 8½-cu. ft. cylinders similarly manifolded for storage up to 2,400 psig, and two 1,000-cu. ft. low-pressure receiver tanks for the collection of helium expended during testing.

There is also a vacuum and perlite insulated 500-gal. liquid nitrogen or liquid oxygen storage tank, plus essential piping, instrumentation, manifolding, safety valves, pressure regulation controls, vacuum protection, bleed valves and polution dampers.

The system can provide helium flows as high as 80 lbs./min. at pressures up to 6,000 psig and at temperatures ranging from —300°F to 165°F. Liquid nitrogen or oxygen, as required by special tests and for use in operating heat exchangers, can be supplied at flow rates up to 100 gal./min. at pressures as high as 100 psig.

All helium used for testing is recycled. It passes from test stations into the two large low-pressure storage tanks, from which it is drawn to be recompressed, dried, filtered and stored in the high-pressure storage tanks.

Recycling allows a significant saving in strategic gases. Absolute system cleanliness is maintained at all times.

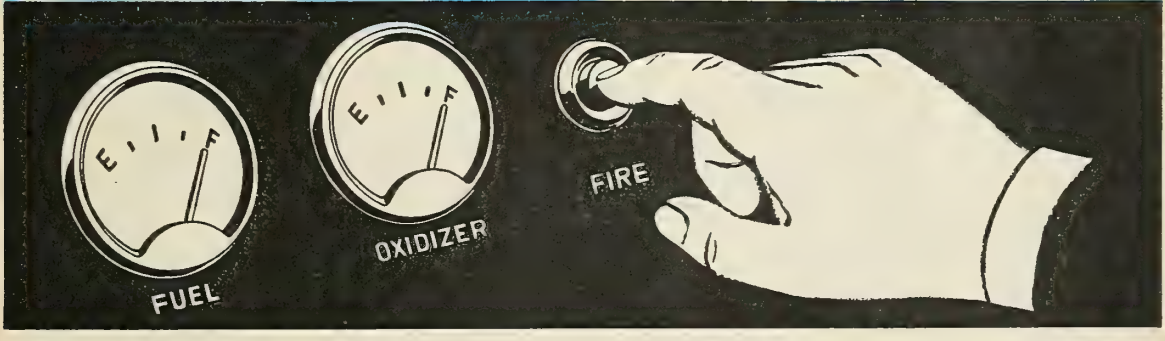
Eldon Fiberglass Adds To Los Angeles Plant

Eldon Fiberglass Manufacturing Co. has added 40,000 sq. ft. of plant facilities to its Aircraft Division at Los Angeles. New plant is equipped for research, prototype work and volume production of fibreglass reinforced plastic parts for missiles and aircraft.



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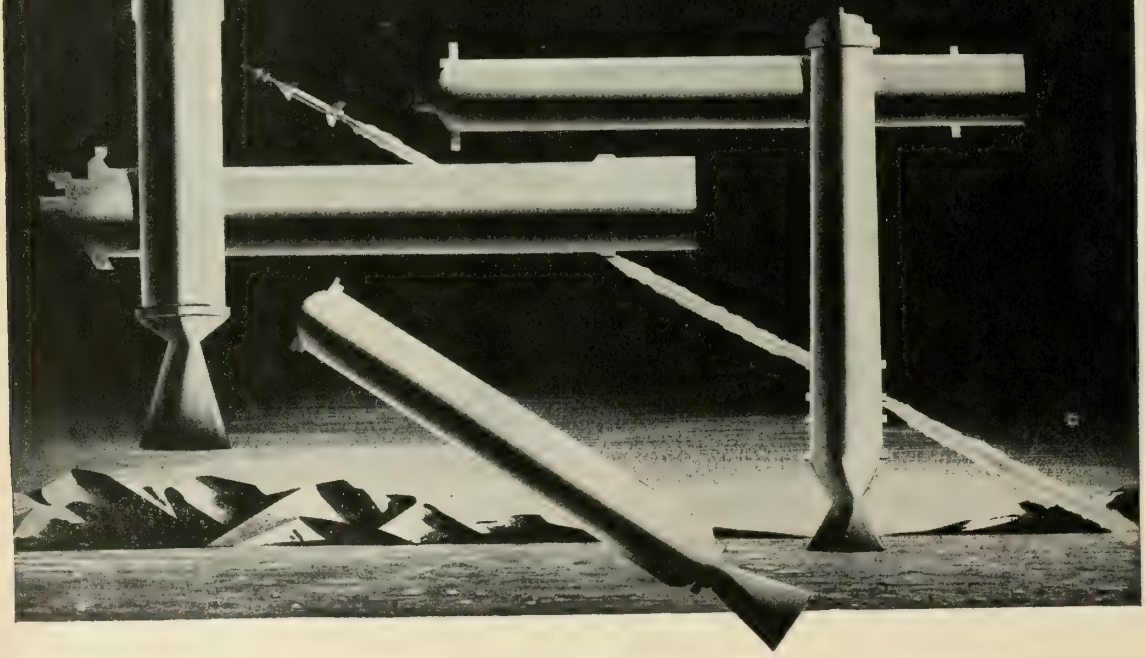
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Outline of 1000 Temperature-Pressure Problems

Any rocket engine looks simple in silhouette—but its 150 or more parts present new and complex problems of operating temperatures and pressures. This is the reason why The M. W. Kellogg Company, leading designer and fabricator of industrial high temperature, high pressure vessels and steam power piping, was assigned a major role in the development and production of over ten different guided missiles to date, including the Terrier.

Steam power piping and rocket motors, for example, have much in common. In the latter, nozzle temperatures are around 5000 deg. F. and pressures 2000 psi. In steam-electric power plants, the Kellogg assignment concerns piping to withstand 1250 deg. F. and pressures over 5000 psi. Both problems include selection or development of not only the proper alloy to provide correct strength-weight relationship and resistance to corrosion or erosion, but also the welding techniques, materials, and skills to fabricate the alloy into large or intricate shapes.

M.W.Kellogg's long fabricating experience with high temperatures and pressures can be a valuable asset to all manufacturers concerned with the rocket program, and to those responsible for process equipment in the petroleum or petrochemical industries.



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Fuels for the Atomic Rocket

by Alfred J. Zaehringer

TODAY'S VIEW of the atomic rocket—a pile to heat a working fluid—is beset by such bugaboos as heat transfer, high temperatures, and corrosion. These problems can be solved by technological breakthroughs or by a painstaking, empirical approach. It is certain however that developments now taking place in the atomic reactor field will form one of the ribs of any future atomic rocket.

Free world reserves of uranium oxide concentrate are estimated equivalent to ½ million tons (some 500-1,000 million tons of ore). This conservative estimate was recently made by the firm of Arthur D. Little, Inc. If one includes presently uneconomical uranium-containing shales and phosphates, the uranium reserve figure would increase. Based on 1958 military production rates, these known reserves will hold out for 25-50 years.

The U.S. now produces 3 million tons of ore each year and will increase it to 5-6 million tons by 1958. Most of this is slated for military purposes. It is estimated that our capacity for uranium will be ten years ahead of any civilian power requirement.

Propulsion

In the U.S., about 70% of our reactor work is devoted to propulsion, mainly aircraft and ships. By 1965 all new naval vessels will be nuclear-powered while the entire U.S. Navy will be nuclear by 1980. Commercial nuclear-powered aircraft will be started by this date according to Arthur D. Little, Inc.

Atomic Fuel

Replacement for chemical fuels is the atomic fuel element. The elements are mechanical structures made of a fissionable material (such as U-235). Atomic fuels are solid or liquid. Most reactors today use solid fuels. Because liquid fuels are more corrosive, much of the present reactor fuel research is with solids.

For the atomic rocket to beat the performance of a chemical rocket, atomic motors will have to operate at temperatures much higher than present 900-1,000 F power reactors. Right now, research is concerned with raising temperatures to 2,000-3,000 F in order to raise efficiencies. It is interesting to note that North American Aviation, Inc. hopes to raise reactor temperatures to over 3,500 F.

The uranium or thorium fuel elements (metallic or metal compounds)

Atomic Fuel Research

Firm	Activity
Argonne National Laboratories Lemont, Ill.	R&D on fuel elements.
Armour Research Foundation Chicago, Ill.	Manufactures elements for Argonne; molybdenum fibers in thorium oxide impacts. R&D work on fuel elements.
Babcock & Wilson New York, N. Y.	Thorium and uranium oxide ceramics.
Batelle Memorial Institute Columbus, O.	Fuel element R&D. Uranium alloys of columbium, molybdenum, zirconium and uranium oxide(di).
Davison Chemical Div., W. R. Grace & Co., Baltimore, Md.	Development of thorium oxide (stands 5000 C).
General Electric Co. San Jose, Calif.	Manufactures UO_2 fuel pellets; ceramic research.
Horizons, Inc., Cleveland, O.	Ceramic fuel element research.
Mallinckrodt Chemical Works St. Louis, Mo.	Uranium metals & alloys. Uranium dioxide clad in zirconium (Zircalloy). R&D on uranium & metal oxides. Aim: uranium dioxide for power piles in 1000-3000 C range.
Minnesota Mining & Mfg. Co. St. Paul, Minn.	Work on Si-SiC elements.
National Lead Co., Fernald, O.	Uranium feed materials refining. Aim: Enriched fuels for power reactors.
North American Aviation, Inc. Los Angeles, Calif.	Research on thorium-uranium and U alloys. Of promise are uranium dioxide and uranium carbide alloys. Aim: Core temperatures of 2000 C.
Olin Mathieson Chemical Corp. New York, N. Y.	Recently set-up nuclear fuel division. Aim: faster production and cheaper fuel elements.
Nuclear Metals Co. Cambridge, Mass.	Working on uranium and beryllium oxides. Aim: intermediate uranium compounds.
Sylvania-Corning Nuclear Corp. Bayside, N. Y.	UO_2 ceramic fuel elements using U-235 or U-238.
Westinghouse Electric Corp. Pittsburgh, Pa.	Metal-clad uranium dioxide ceramics for reactors.



General Electric nuclear propulsion proposals as shown at recent Philadelphia atomic power exhibition. GE is one of the pioneers in this field.

are clad with a wide variety of metals for corrosion protection. Metals include: aluminum, beryllium, chromium, columbium (niobium), copper, nickel, nickel-chromium, magnesium, molybdenum, silicon, stainless steel, titanium, or zirconium.

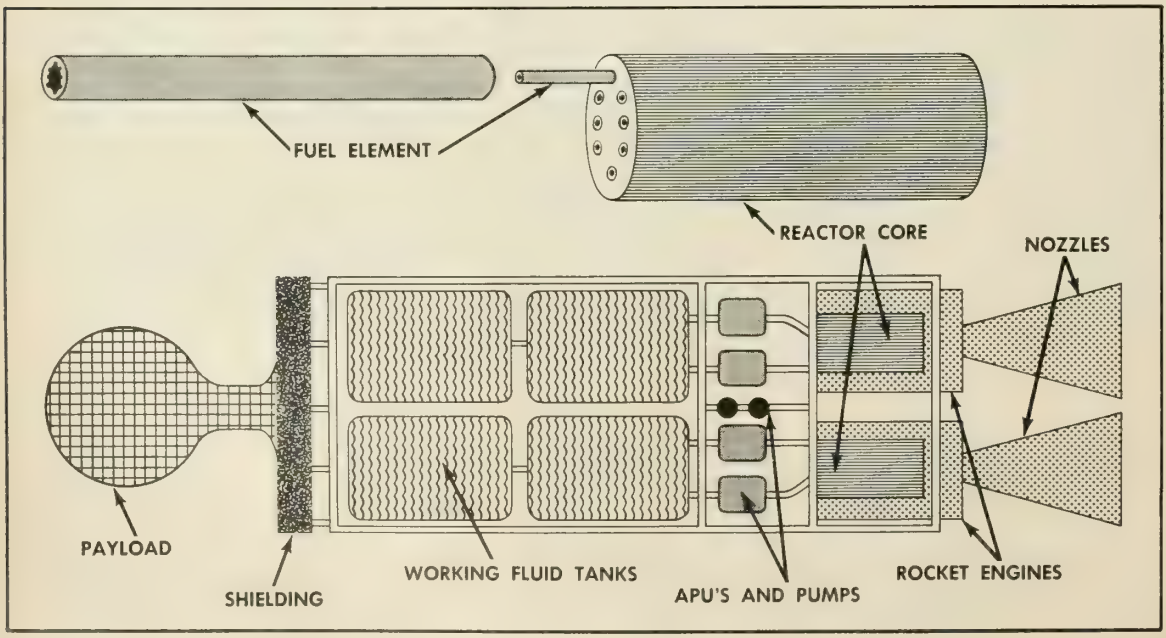
Mixtures of metals, ceramics, and even cermets are also being considered (see table). In considering semi- and non-metal materials, however, thermal shock is important.

Fuel elements of the solid nuclear material may be in pellet, rod, or plate form and are of various hollow configurations. These configurations have to allow the proper heat transfer and also support a chain reaction. The geometry also has to allow for control of the reactor and for easy removal. The fuel has to be "canned" to prevent excessive loss of fission materials.

Present reactors have elements about 4-6 inches in diameter and 4-6 feet long. Several elements are assembled into a reactor core. Not only must the element and core have to stand the high temperatures and corrosion but radiation now lets only 1 per cent of nuclear fuel to be consumed before the element has to be yanked out and replaced. The reasons for this are structural damage by neutrons, and fuel poisoning.

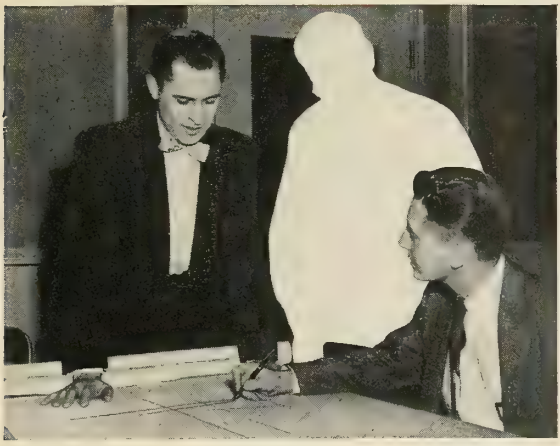
Although the reactor problems associated with the atomic rocket now look like mountains, it is encouraging to note that developments now taking place in the power reactor field are gradually wearing down the mountain.

This growing technology that will aid the atomic rocket include: heat transfer, better high temperature materials and fuel elements, antidotes for fuel poisons, and better radiation-resisting materials. Thus, development of the atomic rocket can now take a free-ride on the rising materials and know-how curve of power reactors.★

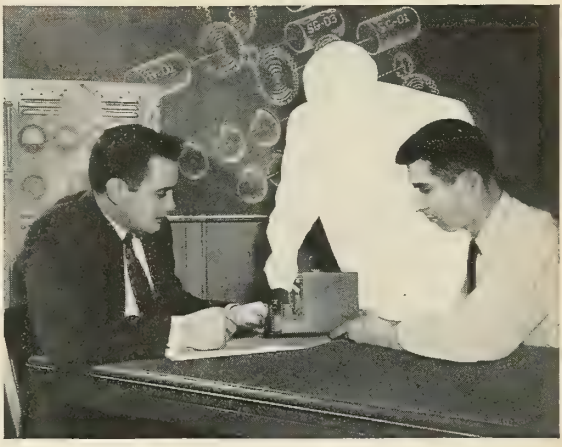


The atomic rocket that may never be built. Although this principle is feasible—we might concentrate on electro-nuclear propulsion systems.

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Test Equipment Engineer: Also promoted recently, this man formerly developed test sets of advanced design, requiring precision electronic measuring circuits and mechanisms meeting military specifications. He started with specification requirements and carried designs through model testing by electronic and mechanical engineers. This activity includes application of servo-mechanisms, packaging of precision components, and liaison with sub-contractors in many fields. *Could you handle his responsibilities?*

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Nuclear Powered Rockets

and the Problems of Heat Release

by Rudolf H. Reichel
Bell Aircraft Corp.

UP TO THE PRESENT our rocket propulsion systems have been entirely dependent on chemical propellants, either in a liquid or solid state. Because of their heat content which results in a specific impulse in the order of 200 to 400 lb-sec/lb, high mass ratios have to be realized in order to fulfill a given mission. This means multi-stage rockets are necessary in many cases. To escape from the earth's gravitational field, or even to bring any payload in a satellite orbit, at least two or three-stage vehicles are required.

No basic change can be expected in the capability of chemical propellants even for liquid hydrogen or fluorine as components. Because the resulting high mass ratios severely restrict space flight, man is looking for higher energy propulsion systems.

A unique power source leading to basically new propulsion concepts has become available with the discovery of nuclear energy. Proposals have been made for example, to use free radicals to produce the reaction $2H \rightarrow H_2$, to heat up an inert working fluid, to produce photons or ions, or to use the nuclear energy of fission or fusion.

It is beyond the scope of this article to discuss which of these propulsion principles are or seem to be realistic. However, it is of great interest and importance to describe the critical factors which govern the application of these "super fuels."

First because of the tremendous heat content of nuclear fuels, e.g. U-235 or Pu-239 yield about 3×10^{10} BTU/lb, it is interesting to study the feasibility of any nuclear-powered rocket propulsion system. If it were not for the numerous technological and shielding problems, doubtlessly very favorable mass ratios would result.

However, this promising situation also has a major drawback. According to the momentum principle, the amount of energy which must be released in the combustion chamber or in the re-

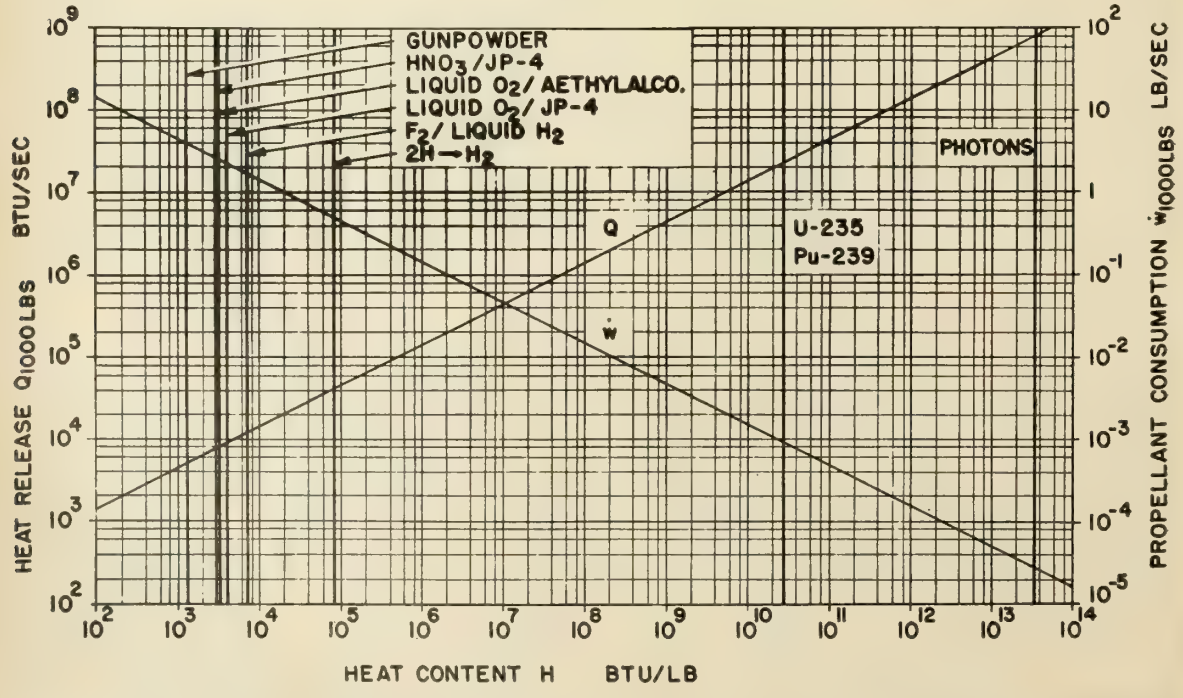


Figure 1 is a full log graph showing heat release Q and propellant consumption w for 1000-lb thrust versus heat content H for different propellants. Heat content of photons assumes the complete conversion of one pound of mass according to $E=mc^2$.

action section of the powerplant in order to generate thrust follows the simple functions of $(H/\eta_i)^{1/2}$ or c/η_i. H represents the heat content of the propellant, c exhaust velocity; η_i internal efficiency of the reaction process.

In Fig. 1 this relationship is presented by plotting the energy Q released for generation of 1000 lbs. of thrust versus the heat content H of some typical "propellants" when the internal efficiency is assumed to be 100 per cent. Moreover, the propellant consumption $\dot{\omega}$ shows that with increasing heat content it has a tendency to decrease as per the relation $(H\eta_i)^{-1/2}$.

For purposes of comparison a constant internal efficiency η_i is assumed. Heat must be released according to the ratio $(H_{II}/H_I)^{1/2}$ or c_{II}/c_I, where the subscripts I and II refer to the propellant contents with II higher than I.

In a hypothetical rocket generating its thrust by fission of U-235, more than 2000 times the energy must be released than is required for an equal thrust motor using common chemical propellants, for comparable η_i. Even for a thermonuclear rocket using the reaction $2H \rightarrow H_2$, about five times the energy would be required compared with common chemical propellants.

In the application of the photonic rocket principle, which is still entirely hypothetical, a tremendous quantity of energy has to be released per unit thrust. About 100,000 times that of chemical propellants is necessary. The area of the photon reflector becomes very large and may become unrealistic in order to keep the surface temperature in a reasonable range.

The application of nuclear power for rocket propulsion obviously would provide tremendous energy quantities. From a pure performance point of view this would indicate great progress. However, the basic law of heat release shows that the quantity per unit thrust increases with increasing enthalpy.

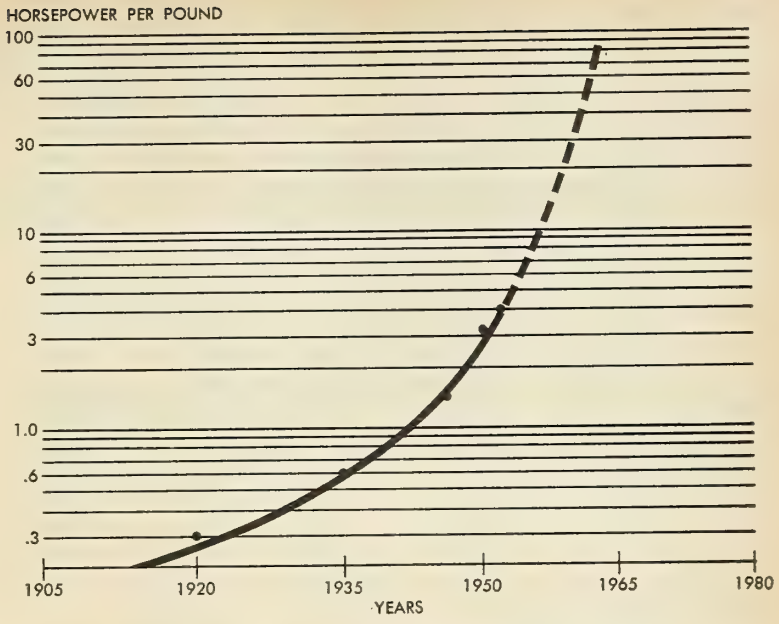
This leads to problems which we currently do not know how to handle. It seems that entirely new techniques of heat transfer are needed in order to deal with energy release problems.

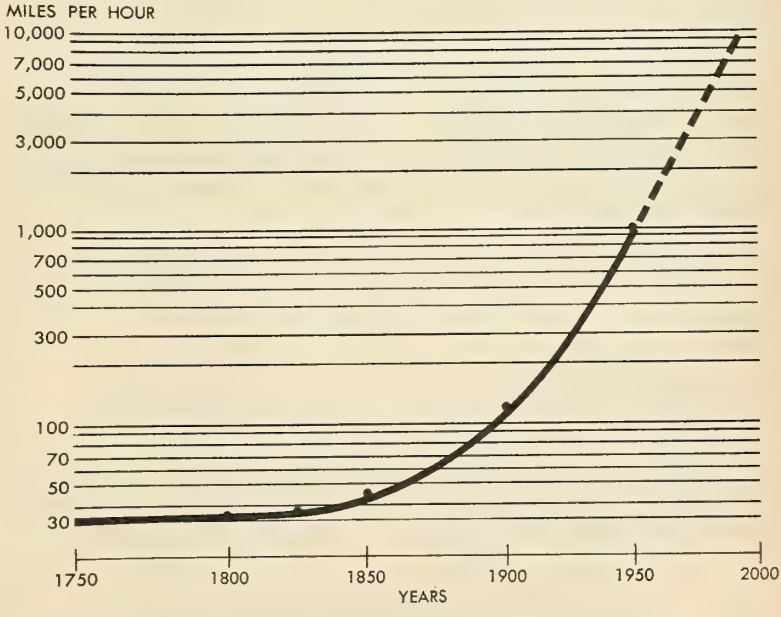
In this connection, the structural properties of materials at high temperatures form a critical factor. It would seem that any solution must probably entail the use of magnetic or electrical techniques now under study.

In addition, since at the temperatures involved virtually all particles of matter could be highly ionized, considerable additional knowledge of heat flow rates, flow characteristics and shock wave phenomena in ionized gases is needed.

Because of the high heat release when high performance propellants are applied, proposals have been made to avoid some of the problems by taking advantage of special applications, such as use beyond gravity.

In this case only a very small acceleration of the vehicle would be required. Therefore excessive reaction temperatures can be avoided and realistic reaction areas are adequate. In order to fulfill the above requirement, the ascent of the rocket from the earth must be achieved by the use of conventional propulsion. ★





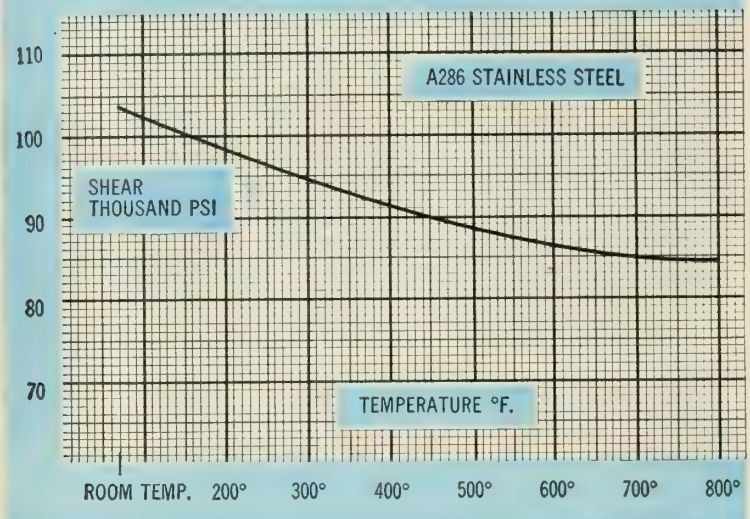
These two half-log graphs provide a dramatic evidence of not only man's quest for greater and greater speed but of his success in achieving it as well. The top graph shows thrust-horsepower per pound of engine weight plotted against time. That below shows the advance of speed records against time. The remarkable point about both of these is that they curve upwards on a log plot. A straight line on a half-log plot is considered to be the normal learning curve. The accelerating rate of rise is evidence of the addition of creative thought to the normal learning process. The successful application of nuclear power to propulsion, directly or indirectly, will sharpen the curve more.

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engineering briefs

Martin Tests Titanium For Hydrogen Content

Martin now regularly tests samples of its titanium for hydrogen content with a Vacuum Fusion Gas Analysis Apparatus developed by the National Research Corp. The apparatus could also be used to determine the amount of various basic elements in other metals.

During the various stages in the refinement of metals, small quantities of oxygen, hydrogen, carbon, and nitrogen are retained or picked up by the metal. Minute amounts of these impurities may produce marked effects upon the final properties of the metal. Good strength combinations are possible with these interstitial alloying elements—oxygen, hydrogen, carbon and nitrogen. However, other properties such as impact and notch-toughness suffer disproportionately.

GE Develops New Leak Detector

A newly-improved electronic leak detector "so sensitive it can detect one part of helium in two million parts of air" has been announced by General Electric's Instrument Department.

Based on an original development for the wartime Atomic Energy Program, the re-designed mass spectrometer leak detector features extreme sensitivity and fast response.

Ten times more sensitive than its predecessor, the new M-2 leak detector finds and locates leaks in vacuum or pressure systems. It is used by electronic industries, nuclear developments, and research laboratories for quality control and production checks.

AF Breaks Ground For ICBM Training Base

Ground has been broken for the first of several technical facilities to be constructed at the Air Force $100 million ballistic missile training base at Cooke Air Force Base, Calif.

Installation is slated to have several thousand military and civilian personnel by December 1958.

Aeronutronic Expands

Aeronutronic Systems, Inc., a Ford Motor Co. subsidiary, has added a 10,000-sq. ft. experimental shop to its Glendale, Calif., plant.

Crucible Steel Reports $1.5 Million Expansion

Crucible Steel Co. of America has announced a $1,500,000 expansion program for Vacuum Metals Corp., division of the company's Sanderson-Halcomb Works at Syracuse, N. Y.

The program, which will double the company's capacity for producing high-purity vacuum-melted materials, will include a vacuum induction furnace capable of producing 3,000-lb. ingots, a melt shop building to house the furnace and additional space for expansion, and a metallurgical-chemical laboratory building for production control and development.

The expansion is being undertaken to meet increased demand for vacuum-melted high-quality bearing and high-temperature alloy steel.

Kaiser Aircraft Gets Contracts

New contracts calling for the production of more than $1,700,000 in guided missile testing equipment are being awarded the Electronics Division of Kaiser Aircraft & Electronics Corp., Toledo, Ohio.

Destined for use by the Air Force, the test equipment allows technicians to make automatic ground check of the operating characteristics of a missile before firing. The pre-flight "Go-No/Go" tester simulates functions of flight.

AF Awards $21 Million For *Navaho* Development

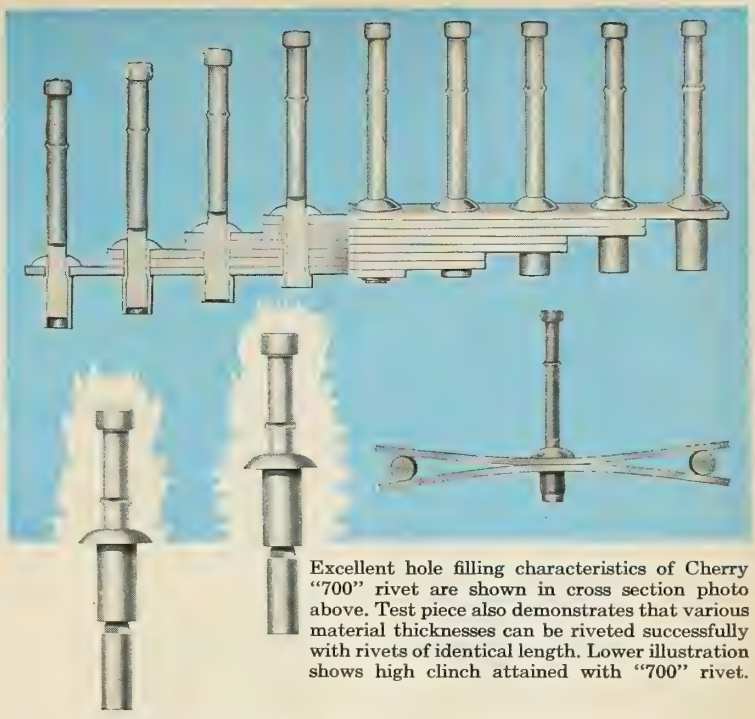
North American Aviation's Missile Development Division has received an additional $21 million for research and development work on SM-64 *Navaho* from the Air Force.

Navaho is currently undergoing tests at the Air Force Missile Test Center in Florida. Testing began after the flight program of the X-10 test missile was completed.

Northrop Employes Get 1 Cent Hourly Raise

Some 14,000 hourly-rated personnel at the Northrop and Anaheim divisions of Northrop Aircraft, Inc., received pay increases of 1¢ an hour effective April 29 as a result of an increase in the Consumer's Price Index.

Northrop's cost-of-living wage program is based on quarterly reviews of the price index. Personnel at the Hawthorne, Anaheim, El Segundo, Palmdale, Edwards Air Force Base, Pasadena, Torrance, Alamogordo, and Cocoa installations are affected. Northrop is producing the *Snark* missile.



Excellent hole filling characteristics of Cherry "700" rivet are shown in cross section photo above. Test piece also demonstrates that various material thicknesses can be riveted successfully with rivets of identical length. Lower illustration shows high clinch attained with "700" rivet.

CHERRY "700"* Aircraft Rivet
Gives More Effective Fastening

The "700" rivet is versatile and in many cases one length of each diameter will cover all thicknesses of material. Also, the sheet hole size is not critical as with other rivets since the design provides positive hole fill even in oversize holes. The stem always adjusts to fill the hole which affords high stem retention independent of hole size.

The manner in which the "700" rivet is set provides high clinch by drawing the sheets together tightly and uniformly. When the "700" rivet is set, the stem shoulder protrudes above the rivet head and gives visual indication that the blind upset is properly formed, the sheet hole is filled and the rivet is properly set.

*Patents issued and pending

The "700" rivet is available in countersunk and universal head styles in a wide range of diameters and lengths. It is installed with standard Cherry rivet guns with controlled-stroke pulling heads and accessories.

This fastener advancement is a typical example of how the Cherry Division has paced the industry with new and improved fasteners and the tools and accessories for applying them—all of which are designed, developed and produced in the Santa Ana plant.

For technical data on how the Cherry "700" rivet will give you a more uniform method of fastening, write to Townsend Company, Cherry Rivet Division, P.O. Box 2157-Z, Santa Ana, California.

CHERRY RIVET DIVISION

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In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

Circle No. 32 on Subscriber Service Card.

Missile Arming Solenoid tested at 115,000 ft.



A new arming solenoid, qualified to MIL specifications has been tested at altitudes to 115,000 ft. Designed specifically for arming of a missile on a very high performance fighter, the solenoid can be adapted to other applications. The compact unit weighs only 11 oz., has a normal power drain of 0.7 amps and operates at down to 18 volts. At −65° F and 29 vdc power drain is only 1 amp. Operating temperature range is +250° to −65° F.

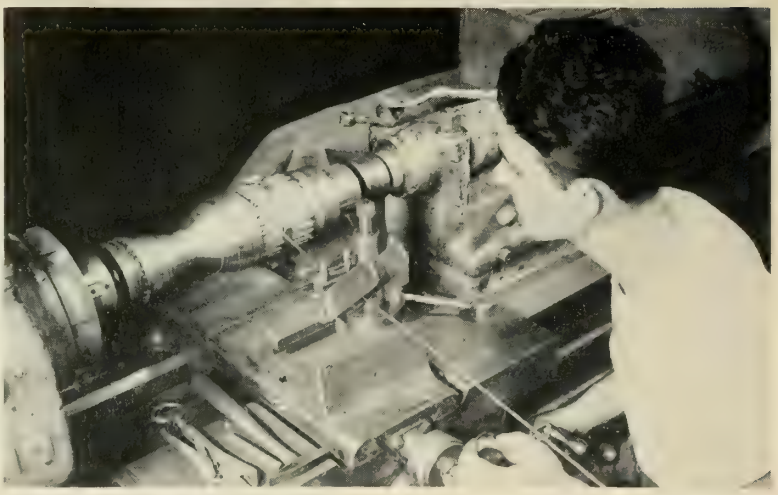
While specifications required testing to a lesser altitude, the solenoid was tested at 100,000′ and 115,000′. At 100,000′ altitude 700 RMS 60 cycle current was applied between winding and case for more than a minute. There was no corona discharge, arcing or shorting. At 115,000 feet the test was repeated with voltage being increased at a rate of 25 volts/second. At 825 volts a corona appeared suddenly. Apparently based on electron emission there was no sharply defined path of high conductance. Subsequent retesting of the identical unit showed no damage resulted from the 115,000′ test.

For further information on this high altitude solenoid write to:

STRATOS
A DIVISION OF FAIRCHILD
ENGINE AND AIRPLANE CORPORATION

Western Branch: 1800 Rosecrans Ave., Manhattan Beach, California.

NACA Studies New Fabrication Methods



NACA 5000 lb. thrust rocket chamber in NACA sheet metal shop at Lewis Flight Propulsion Lab. This rocket chamber is wire-wrapped and then braced to provide extra structural strength.



Spun chamber with outer channels for fuel flow control. Left, casing. Right, throat.



Chambers left to right: Spun, finished, corrugated, hydraulically or cast formed, chamber with flow directors braced on and outer casing suitable for any type rocket chamber. Further information is available by contacting NACA and requesting NACA Technical Note 3827.



Aerophysics

By Seabrook Hull

A nose cone that melts or burns but remains lethal to the point of detonation continues to be the only feasible solution to the medium-to-long-range ballistic missiles. The same temperature-materials restrictions that put a known top limit on the efficiency of conventional liquid, solid and (soon) jellied chemical rockets also restricts nose cone design. There is not and may never be a material that will permit the design of a non-deteriorating warhead for IRBM's and ICBM's.

Post-World War II research into high temperature materials has shown that none remain solid beyond about 3500°C. This is a function not of man's ingenuity in devising new molecular combinations (which would give hope of a major breakthrough someday) but of the bonding forces of one atom for another. It is a matter of basic physics, not chemistry. The practical limit for the structural use of any material is 3000-3200°.

It is conceivable that the space ship of the distant future, making a fast reentry, may employ intense magnetic fields to shape ionized and dissociated gases into heat shields for its nose. But it is not practical to consider for the "ultimate" weapons of today.

W. R. Warren, General Electric's Missiles and Ordnance Systems Department, in a paper, Hypersonic Experimentation, indicates the ball-park conditions surrounding reentry: "For typical values, if the flight Mach number is 16 and the altitude is 100,000 feet the temperatures immediately behind the shock front and at equilibrium are approximately 15,000°K and 6000°K, respectively."

Since materials cannot be looked to for the final answer in nose cone stability during reentry, aerodynamic design to minimize heat transfer is of prime importance. Recently devices for studying hypersonic flow and heat transfer have increased both in number and utility. These include the wind tunnel, shock tube, shock tunnel, plasma jet, shaped charged accelerator, rocket exhaust, solar furnace and the hypervelocity mass accelerator. This last, by timed electrical discharges into helium gas behind a piston holding the model, is capable of uniform acceleration to 60,000 ft/sec.

And for possible hypersonic flight application, two new materials: a crystalline material made from glass, now in the pilot production stage; and a ductile ceramic in the laboratory stage.

Pyroceram, a family of "extremely hard, fine-grained crystalline materials formed from special glasses," has just been announced by the Corning Glass Works as having "good mechanical strength, excellent electrical insulating properties at very high frequencies, high deformation temperatures, superior thermal shock resistance, and hardness." They are susceptible to conventional forming methods.

Under an AF Office of Scientific Research contract, E. R. Parker, J. A. Pask and J. Washburn at the University of California have produced in the laboratory single crystals of magnesium oxide (melting point, 5072°F) that are ductile. This was done by special surface treatment. While theoretically these crystals could be grown to any size and machined to desired shapes, work is accelerating on inducement of ductility into polycrystal structures.

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Shielding of critical areas and equalizing of heat enabled DOVAP to operate at higher temperatures than specified... without benefit of cooling by either conduction or convection.

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Where momentary loss of signal means the end of usefulness, DOVAP functioned unfailingly... under environmental conditions of shock and vibration more severe than specified.

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Withstanding torture is a specialty of Packard Bell's Doppler Velocity and Position indicator (DOVAP), designed and developed for an inter-continental missile (classified). In prototype environmental tests, this high powered Doppler Transponder was subjected to temperature, shock and vibration beyond the extremes expected in flight... beyond the extremes called for in specifications.

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Spaceman Col. Bill Davis

Details Absolute Limits of Chemical Rockets
Suggests Magnetic Ramjet for Orbit and Escape
Emphasizes Need for More Relativity Studies

Colonel Wm. O. Davis, USAF, is Deputy Commander, Operations, Air Force Office of Scientific Research (ARDC). He's also a senior pilot having ended up World War II as a B-24 squadron commander—a member of Phi Beta Kappa and Sigma Xi and holds a Ph.D. in Nuclear Physics. But perhaps his greatest contribution to the future and security of the nation is that he has gathered a group of men under him who are not only willing to tackle the impossible but will try a new approach to it as well. Great scientific achievement never derived from wearing blinders.

Q. *Col. Davis, can you give us some idea of the future of propulsion, the practical limits on rockets, for example, and what comes after?*

A. The basic problem is fairly straightforward. Right now, all propulsion systems have one thing in common: They're heat engines. Heat, by definition is a random process, and when I heat a gas, whether to push a piston with it or to simply squirt it out the back end, basically I have one serious problem: My energy is going in all directions. A large percentage goes into the structure as heat.

This leads right to the fact that you are limited by materials. I don't know exactly what is the best material we've got now, but for sustained operations it's probably good to somewhere in the neighborhood of 1500° to 2000° centigrade. In the course of time we may be able to double that—up to about 3000° C.

Q. *What kind of material would that be?*

A. Probably magnesium oxide or something like that. Carbon goes to about 3200° C. Above 3500° C any material is in a gaseous state. You're not going to make an alloy or a ceramic or anything else out of gas. This is the end of the line. There isn't ever going to be a 10,000° C material, unless you actually learn how to modify an atom.

Q. *Where does that leave us?*

A. Well, if you double the temperature at which a solid or liquid rocket—any rocket based on heating a gas—can operate, by the equations of rocketry, you only increase your exhaust velocity by the square root of two. In other words a 40% increase in specific impulse is all that can possibly be expected, no matter how good the propellant is. It makes no difference whether I do this with ordinary chemical fuels, free radicals, nuclear piles or any other source. Where I heat and expand the gas through a nozzle in the way a rocket does. I'm limited to a 40% increase.

Q. *40% over what?*

A. Over what we now have in the way of a rocket.

Q. *Is it practical to think of putting a man in space at this time?*

A. Yes, for certain types of objective. For example, to pinpoint the location of, say, a satellite, if you rely on transmitting from the earth to the satellite, your uncertainty of where it is is quite large and at the distance of the moon or anything farther, your knowledge of its location is very poor indeed. You're faced with the fact that you're going to have to transmit and observe from the vehicle.

It may turn out, surprisingly enough, to be somewhat easier to do this with a man. Problems of communication, navigation, maneuver and return to base—for that matter, the interpretation of information—may be made an awful lot easier with a man than it will be to design automatic equipment to do it.

Q. *How would you put a man in space?*

A. The limiting factor of just about 40% more exhaust velocity is ultimately going to prevent you from using a heat engine. It will be neither safe nor economical. All right, what other properties do I have to work with? Electricity and magnetism are a possible approach.

With an electric or magnetic field I can make my particles go in a straight line, rather than just heating them up in a random way so that they push against the walls of the chamber in all directions and heat it up. Electrically or magnetically I can make them go in just the direction I want. I can use all the energy I've got effectively.

Q. *Won't this concept almost invariably require a conventional rocket booster in order to build up initial escape velocity?*

A. No. This is another thing that bothers me. People are under the illusion that the only way to get off the surface of the earth is with a straight up, 10 *g* blast off, or something of the sort. This goes back to a concept that was laid down and developed in about 1924.

I would start with an air-breathing engine, either an ordinary turbojet or a ramjet or a combination of both.

What I want to buy first of all is altitude, and I want to use a propulsion system which is most efficient for that purpose. Secondly, having gotten altitude, and not before, I want to buy speed. Speed at sea level costs too much. I wait until I'm up 150,000 feet or so; then I buy my speed.

Q. *Can you attain escape speed in a ramjet?*

A. Not necessarily with an ordinary ramjet by itself, though I could get some pretty high speeds, perhaps Mach 5 or 10. There I have reached maybe 150 miles altitude where most of the air particles present are charged.

Q. *Would you then cut in your ion propulsion system as a kind of boost to the ramjet?*

A. Yes. As I reach this region where I have charged particles available I will begin to apply part of my total energy magnetically. I'll just begin to. Then, as I go higher, I'll get an ever increasing portion of my thrust magnetically,

until I reach an altitude where the thermal aspects of a ramjet won't be effective. By this time virtually all the gas is ionized—multiply ionized. Now I'm going much faster, so that the total volume of gas going through that I can act on is getting greater.

Q. *Well, using the ionized air at altitude in this way, don't you end up with a kind of magnetic ramjet?*

A. Yes. I don't know whether what anybody has in mind right now is practical or impractical, but I'm convinced that one way or another we're going to find out how to use electricity or magnetism for thrust. And, I think the logical way to do it is magnetically. If I use my energy to create a magnetic field that works against a charged gas, I can probably get orbital velocity within the atmosphere—at an altitude somewhat below 500,000 feet and just coast off into an orbit.

Q. *Now you've set yourself a kind of linear accelerator out in space. What's your power source?*

A. I have to carry it. This is where the true value of nuclear power really begins to be felt—as a source of energy. I can carry it with me and run it indefinitely.

Q. *Though space is popularly thought to be "empty," we understand there are charged particles out there. Is there any clue as to whether there are enough so that at very high velocities we can use them to effectively supplement the working fluid?*

A. According to Professor Fritz Zwicki of Cal Tech, yes. These particles would be very highly charged—many times ionized and probably stripped of all their electrons. He says that if you get going fast enough, you can scoop in enough of these things to where you get thrust out of them.

Q. *Would your working fluid be hydrogen?*

A. It depends on the velocity I get. I think that you would find that your working fluid would vary with the size of your vehicle and how far you wanted to go. Say I have the capability to accelerate my working fluid to a tenth the velocity of light. As soon as I get into this ballpark of exhaust velocities I have to worry about Relativity.

I've got to remember that what I'm after is not exhaust velocity which works fine at the lower exhaust speeds. I'm after momentum transfer. In other words as I begin to try to make the exhaust go faster, and I get it fast enough to where Relativity enters in, instead of making it go faster, I'm merely making it heavier.

Q. *Under the principle of conservation of energy, won't your momentum continue to increase proportional to the energy fed into the system whether it does so because velocity goes up or because mass goes up? Momentum is simply mass times velocity, isn't it?*

A. Actually momentum is mass times velocity only at relatively low speeds. The theory of Relativity defines momentum as $P=m_o v/\sqrt{1-v^2/c^2}$. Thus when v, velocity is small with respect to c, the speed of light, the equation reduces to simply the product of the mass and the velocity. However, when, v equals c, the momentum becomes infinite. However, in answer to your question the momentum will continue to increase proportional to the energy fed into the system but not in the same way it does at low speeds.

Q. *On this business of Relativity, as we start thinking seriously in terms of space flight and the velocities it implies, doesn't Relativity begin to become not a theory for possible application to basic research but a matter of practical, operational consideration. For example, according to Relativity the only limit on a space vehicle's velocity is its own observation of the speed of light. Yet this is constant at 186,000 miles per second no matter how fast the vehicle goes. On this basis, is there any limit to how fast man will be able to go in space?*

A. Well, once you leave the earth, you will still exist in a frame of reference—the solar system, the galaxy or something.

Q. *Suppose you close yourself in and refuse to consider any frame of reference but your own—just calculate your acceleration on the basis of classical mechanics?*

A. Under these conditions you will observe a constant acceleration but since your measurement of time is changing with respect to the earth it works out to give the same answer. In other words I appear to have a constant acceleration in my frame of reference but since my measurement of time is changing with respect to the earth, my earth-measured acceleration appears to decrease.

Q. *What I'm wondering about is whether or not there aren't too many scientists who tend to accept Einstein's theories as the last word?*

A. Einstein himself said many times that there was no doubt in his mind that as time passed on his theory would be shown by somebody to be merely a special case of a more general theory. I don't think he ever had any feeling of an immortal theory, but a lot of people do and this is understandable—It's what they learned at school.

Q. *This proposal to send a small rocket around the moon—Is it practical to consider it at this time?*

A. Let's put it this way: We have the technical capability to do it.

Q. *In the case of so-called anti-gravity, what is the actual research and development situation there?*

A. First of all, there is a very great deal of misunderstanding of the whole question of gravity. We are very much concerned with its study. The Air Force works in the gravitational field at all times. Anti-gravity or what-have-you might possibly someday result from such studies. However, there's an illusion as to what you would buy with so-called anti-gravity.



. . . a 40% increase in specific impulse is all.



It may be easier . . . to put a man in space.



What I want to buy first is altitude . . .

One feeling is that all you've got to do is paint anti-gravity on the bottom of something and immediately you rise to the moon. But this is phoney, because nobody has ever suggested we're going to do away with the conservation of energy, and if I'm going to lift a pound 100,000 feet, I'm going to expend 100,000 foot-pounds to do it. I'm going to have to supply exactly as much energy to do it with the gravitational field as I'm going to have to apply to do it with a rocket.

There's no way I can get away from it. The only advantage I might gain is a more efficient use of energy. Clearly if I have a nuclear source, I can generate electricity or what-have-you. If I could now apply this to direct interaction with the gravitational field, presumably I could rise more efficiently. The mere fact that I can control the gravitational field won't mean that I can get something for free.

Q. *But you do have conditions where you do, in effect, get something for nothing. The crystal radio set is an example. True, energy is expended and it had to be produced somewhere, but you as the user of the receiver don't have to supply it. Might it not be theoretically possible for a vehicle in flight to get part of its energy elsewhere in a similar manner?*

A. Well, this is perfectly true, and I'm not ruling out that you can't do something useful with the gravitational field. Certainly when we progressed to the point where we could generate an electro-magnetic field, we could do a lot more than we could with a lodestone.

In particular there's one neat little trick that has always appealed to me. Whether mass is positive or negative, it still goes to infinity at the velocity of light. In the Special Relativity equations, on the other hand, if my mass is zero the equation becomes interderminent.

Suppose I could so shield my entire vehicle from gravitational influences that to an outside field its mass seemed to be zero. Under these conditions, it appears, I would have no velocity limitations. It would be a very nice thing to do, but it's not the answer to all problems.

Q. *The Air force has some contracts out now for studying ion and photon propulsion systems, doesn't it?*

A. Nothing on photon propulsion, but we have several people working on various aspects of ion propulsion. What we're trying to do now is not to build a rocket but to study the properties of electrically charged gases at very high densities—how to handle them; how to accelerate them; how efficient is the process; what are some of the problems. This can be done in the laboratory, and done rather cheaply. The plasma jet is very useful.

Q. *Is this the same plasma jet they use for nose cone testing?*

A. Yes. Such a jet can be used for a lot of things. This is a nice way of producing about 20,000 degrees Fahrenheit for cutting very high temperature materials or for melting materials that can't be melted any other way. You can also use the same plasma jet to do experiments on ion acceleration and on the control of large bodies of ionized gas at high densities.

Q. *When you try to accelerate a plasma flow either electrostatically or magnetically don't you have a problem with mixed negative and positive ions?*

A. Yes. Admittedly you're accelerating one group of particles in one direction and one in the other, but in general your positively charge particles are carrying most of your mass. So while you balance your charge, your momentum has to be conserved. It is not a complex problem to collect your negative charges, which are mostly electrons and simply reroute them so you exhaust them in the same direction as the rest of your flow.

Q. *What about electrostatic control and acceleration of your ions?*

A. We're not particularly enthusiastic about the classical approach to ion propulsion, which is simply electrostatic, where you have a large potential difference, and you accelerate particles along this potential difference. Reason is that as you begin to get a lot of current in your ion jet. It becomes an almost perfect conductor.

It's nearly impossible to maintain your potential difference. Furthermore, even if you could, at these very high voltages there's a tendency to start collecting electrons around the terminal. The space charge would defeat you. In other words, you'd eventually be pulling your exhaust gases back into you.

Q. *With excessive voltages wouldn't you also generate some very high intensity X-rays?*

A. You very well might. Thus magnetic acceleration looks a very great deal more promising because you get high energies, but you stay away from high voltages.

Q. *How do you think development along this line will progress time-wise?*

A. Assuming you begin to get a pretty good feel for how you best go about accelerating charged gases, one of the next things you might want to do would be to stick something on somebody else's rocket and see whether you get any positive thrust, and if so, how much.

Q. *What is your objection to photon propulsion?*

A. I'm not terrifically excited about it because basically you still come back to the fact that it's a heat engine. You can't charge a photon and accelerate it magnetically. There's the same old problem of materials limits.

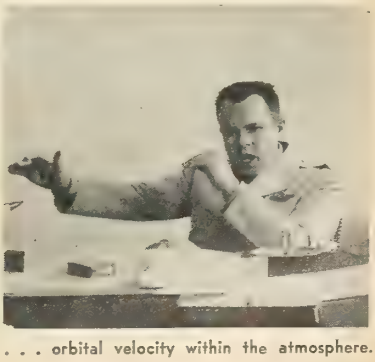
Q. *Do you think you'll run out of developmental potential in the chemical rocket, considering problems of lead time, etc., in, say, ten years?*



Then, not before, I want to buy speed . . .



Electricity . . . a possible approach.



. . . orbital velocity within the atmosphere.

A. We're going to run out in a lot less time than that, you see, because just the trend curves themselves show you that in all probability you're going to want what comes after much sooner than most people realize.

Q. *Conceivably then, you will have ion propulsion weapons systems working well before the 1970's.*

A. Well, if the principle is sound. The whole thing that confuses people is the length of time it takes to engineer something versus the length of time it takes to have a new idea. Suppose in 1938 I had decided that I wanted to drop charges consisting of 20,000 tons of TNT: I could have spent the next 50 years trying to develop an aeroplane to carry it. But a simple new concept gives me the capability to accomplish that particular job in much less time.

Q. *Can you indicate moneywise how much effort is being put into ion propulsion?*

A. It is very small. And even the effort going into ion propulsion, since we are a research organization, is not necessarily related solely to ion propulsion. The work with plasma jets can be useful in many ways. You want to find out its properties. You don't say this percentage of our program goes for ion propulsion. For example, the earliest work in magneto-hydrodynamics now contributes to this knowhow.

Q. *Magneto-hydrodynamics—what's that?*

A. A fluid which consists of charged particles behaves differently from an ordinary fluid because as each particle moves it generates its own little magnetic field, which in turn causes motion on the part of an adjacent particle which is also charged and also generates a field. You not only have a damping effect but an entirely different method of transmission.

For example, a magneto-hydrodynamic shock wave will transmit itself in an entirely different manner from a normal shock wave. This field of study had its origin in astrophysics. So, would you say research into magneto-hydrodynamics was part of your astrophysics or part of your ion propulsion budget?

Q. *By when do you think there will be an operational requirement for an ion propulsion system?*

A. Let's face it. There never has been a new concept developed because of a requirement. Somebody discovers something new, and then says what can I do with it. I will say this, however. If at some future time—and this might be two years from now if we're lucky and everything we've got under way proves to be fabulously successful; or it might be five, ten or fifteen years from now—we are suddenly in a position to say: Look, here is a new propulsion concept, and it's been demonstrated in the laboratory; it will work and it will give you the following capability. When this happens, in a very short period of time somebody will have established a military requirement for it.

Q. *When do you think we'll leave the heat engine? When will the next hike in speed and altitude, the step into space, require that we have something else?*

A. There's always an intrinsic military requirement to do the next thing. It would be nice and convenient if this weren't so, but its the nature of the beast. As soon as you think you understand a military environment fairly well, the enemy outflanks you, and this is a strategic war we're fighting.

This business of scientific research may seem quite far from the battlefield, but actually, we're at war now. People who fly airplanes and drop bombs are preparing for it. In the laboratory, we're at it. We're at war.

We have entered space or certainly are about to with military vehicles. It is becoming the next major military environment. There is an intrinsic necessity that we understand this new environment and that we understand it first and that we understand it best. Every other military environment that's ever existed always had the same start.

We can't sit around and wait until the last minute. This is too expensive. We're going to have to evolve a new military concept before the fact. So, in this sense there already exists a military requirement for a non-thermal propulsion system. It's not a formal one, but in the sense that it's related to future progress it exists.

Q. *What's the commercial application, if any, of such things as ion propulsion?*

A. Well, consider the problem of going faster and further, whether it's for military or commercial purposes. A very large percentage of the total energy you're using, whether it be in the gasoline engine of the DC-7 or what-have-you does nothing else but overcome drag. And the faster you go the higher drag gets.

It is inherently cheaper when I want to travel great distances, and particularly if I want to do it fast, to go high first and then go fast, rather than try to beat my brains out against an atmospheric wall. These propulsion considerations are not entirely related to just some future far-off time when we're going to be fighting a war in space, they're related to the national economy. We're consuming our natural resources at a tremendous clip. How much can we afford to throw away?

Q. *Who gives the go ahead to start building towards a space force?*

A. It is not our job to decide whether the United States is going to build a space force. Somebody at some future time, and it may not be too far away, is going to have to face a decision at a very high level. Somebody is going to have to take note of the fact that the Soviet Union is heavily in the business of astronautics.

Somebody is going to have to decide if it is or is not worthwhile from a military point of view to push such a program. Now, we don't make that decision, but on the other hand you can't make it in the absence of facts. You first have to know what is the real capability. How much will it cost? What are the problems? How much of the national economy is going to have to be diverted?

Q. *Do you find it hard to get support for this kind of research?*

A. Within the last few years our top management has shown a very, very enlightened attitude. It's been quite remarkable that people have been able to understand this type of research. We've gotten excellent support out of the Air Staff and out of General Power in ARDC; also from the Assistant Secretary for Research and Development. We've gotten excellent support from every level.

Q. *You're primarily a basic research organization?*

A. Yes, but we do have a philosophy of management here which says that we believe we have to do more than just support basic research. If all we do is support it, we might as well turn our money over to somebody else and let them do it, but because of the fact that we are supporting basic research, we have a magnificent input of information in every field of science, and therefore with a very small group of people, we're in a position to try to synthesize results coming in from every field.

Q. *This provides you with an excellent opportunity, but doesn't it also require that you and your staff maintain completely free and open minds?*

A. Yes, and we have fought for this for a long time. This is not a casual accident. It's taken a great deal of effort on the part of a lot of people to develop and maintain this opportunity to work in the particular way that we do. ★

From Redstone to Jupiter

Army Philosophy in Development of Ballistic Missiles

by Dr. Wernher von Braun
Army Ballistic Missile Agency

THE BASIC CONCEPT behind the *Jupiter* development is that it is the natural and logical next step after development of the *Redstone* missile. The well-tested and successful *Redstone* became a natural test-bed for guidance and other components of the *Jupiter*. *Jupiter* components of all kinds have been test-flown in modified *Redstone* missiles.

We have conducted captive runs with complete *Jupiter* configuration on the test stand, and obtained an average of several hundred different measurements per run. These furnished information ranging from powerplant performance to intimate environmental data such as the vibration pattern on a certain spot in the missile where sensitive equipment will be mounted. Such captive test information, in addition to *Redstone* flight test results, leaves very little to chance.

This wealth of test stand in-flight experience, coupled with the methodical testing and evaluation of all components, enables us to feel quite confident about the forthcoming flight-testing of the *Jupiter* missile itself.

The Army has pursued a minimum-risk program in the development of the *Redstone* and *Jupiter* ballistic missiles which provides optimum development and performance.

Basically it provides for the thorough testing of every component and minor and major assemblies, prior to launching of the missile.

There is a tremendous difference between delivering a block of research and development missiles to the proving ground, and firing them successfully on schedule. The former is essentially a question of shop capacity. The latter depends on the capability of the engineering team to evaluate flight results correctly and rapidly, make necessary changes, and furnish the modified missiles with a sufficient degree of reliability to the firing crew.

This development cycle—discrepancies uncovered in flight tests leading to modifications of further test missiles which are half-completed on the assembly line—is quite slow, thus it is difficult for even the most closely integrated team to keep the experimental missiles firing at frequent intervals.

The Army's *Redstone* and *Jupiter* missile programs are being handled by a closely-knit and tightly integrated team with many years of experience in the ballistic missile field. This team consists of experienced scientists and engineers of virtually every field involved in this relatively new art. It includes rocket engine men, structural engineers, physicists, aerodynamicists, gyro experts, electrical network specialists, as well as test stand engineers, tool designers and fabrication experts.

Such an integrated team is more than just a group of specialists working on the same premises. It is comprised of men who have what I call "practical systems experience," men who are familiar with the intimate functional cross-relationship of guided missile components, who know how an observed deficiency in their area of responsibility may affect an entirely



A production ballistic missile, REDSTONE is being weaponized for issue to field forces.



REDSTONE being hoisted into firing position.

different part of the missile. We thus have within the organization our own systems engineering group.

The need for utmost flexibility during the research and development firing period governs our design philosophy. We expect occasional surprises and setbacks, and the resulting need for modifications between test firings.

We do not believe it is wise to plan too high a rate of initial firings, nor to release too large a number of untested missiles to the production shops for the early flight testing phase.

We believe that by setting early production aims too high there is a very real danger of "drowning in one's own hardware." Too much hardware too early will tie up the bulk of shop manpower with the modification of half-completed missiles which failed their flight tests.

Our schedule called for a limited number of development missiles in the early phase, but for elaborate instrumentation and a maximum of telemetering. An extended inspection period, supported by comprehensive check and recording equipment, permits flight simulation for every missile and virtually all components.

We static-fire our missiles prior to final inspection and shipment to the firing site. This allows us to call freely on the design and development engineers for correction of any defects encountered. It also minimizes the strain on the proving ground facilities.

The proper places for shakedown testing of large ballistic missiles are the static test stand, the electronic simulator, the structural and mechanical test laboratories, and the environmental laboratory. Large missiles are too costly and too dangerous to be flight tested until every key man in the development is honestly convinced that he has exhausted every ground method of uncovering any deficiency.

Early development vehicles should be designed to use readily available and economical materials and construction processes, with final product engineering proceeding as a certain volume of experience is accumulated.

All the guided missile experience to date, including that on the *Corporal*, the *Nike*, and the *Redstone* indicates that this procedure is an effective and economical one for guided missiles. This becomes readily evident by comparison of preliminary layout and the final, operational product of any of these missile systems.

Close liaison is maintained with the production prime contractor during all stages of development. Thus production can begin almost immediately at any stage of the design.★

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Photos, courtesy Ballistics Research Laboratory, Aberdeen Proving Ground

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Chemical Aspects of High-Energy Solid Propellants

By Alfred J. Zaehringer

VIRTUALLY ALL modern solid propellants can be considered in the high-energy class. The performance range is from a specific impulse of 180-225 sec. The average Isp is probably at the 200 sec mark. This corresponds to a heat of combustion of about 1.0 kcal/g for typical systems.

During the past ten years the performance has increased some 40-50 sec. However, during the next ten years, we will be doing well to drain an additional 25-30 sec. The probable practical limit for conventional solids will be under 300 sec.

The reason: we are running out of good, *stable* chemical systems which can yield enough energy. In addition, such important factors as physicals, ease in processing, and cost are becoming increasingly important.

In essence we now have two types of solid systems. One, homogeneous propellants, have oxidant and fuel (reductant) combined in one molecule or mixture of molecules. Binding is largely a result of the chemical bond.

The other approach has attempted to strengthen the bond by use of plastic fuel-binders. Here, in heterogeneous (or composite) propellants, we have a separate oxidant compound bound together with a plastic adhesive which also serves as fuel. Fig. 1 schematically outlines processing techniques for both classes of propellants.

In general, the properties of the mixed propellant will determine how the grain is to be formed. For very stiff mixes, hot or cold milling may be required. Extrusion can be used with solvent systems or heavy composites. The general aim now is to arrive at castable mixtures, viz., mixes which can be poured (like concrete).

Techniques used in making castable propellants are exactly the same as for making concrete. In all modern systems, then, we no longer have "powder" rockets. Although powders may be used, the finished propellant derives its "solidness" from chemical bonds rather than from mere mechanical bonds. Thus, literally, modern solid propellants are really solid.

The first breakthrough beyond the ancient black powder came with the discovery of nitrocellulose around 1830. Nitrocellulose (cellulose nitrate is the more correct chemical name) combines both oxidant and reductant within the some molecule.

Normally it has a fiber-like structure. By use of solvents, other materials, and mechanical work, nitrocellulose can be formed to give tough, plastic-like grains. However, the energy release was fairly low and, more important, nitrocellulose is an unstable molecule even when very pure.

Stabilizers (such as diphenylamine) were found to prolong storage life and later nitroglycerin was added to increase the energy content. However, addition of nitroglycerin was a costly affair: it not only increased the price but also made the propellant much hotter burning and also more sensitive to shock and temperature.

Since both single and double base propellants were formed with the aid of solvents, solvent removal with larger and larger grains became more and more difficult. The newer solventless systems now offer almost unlimited grain sacle-up.

With plastics technology growing steadily after World War I, the solid oxidants (Table 1) were eyed seriously by researchers in a number of countries. The old GALCIT binders (asphalt-oil) and NDRC types (cellulosics or phenolics) are now familiar to all.

Late in the war, two important fuel-binders were added: the polyesters (Aerojet Aeroplex) and the polysulfides (Thiokol). It may be assumed that these materials form the backbone of most present composite systems.

Unfortunately, we are stuck with a meager number of good oxidizers at the present time, so, in the composite field at any rate, one might consider looking for better fuel binders.

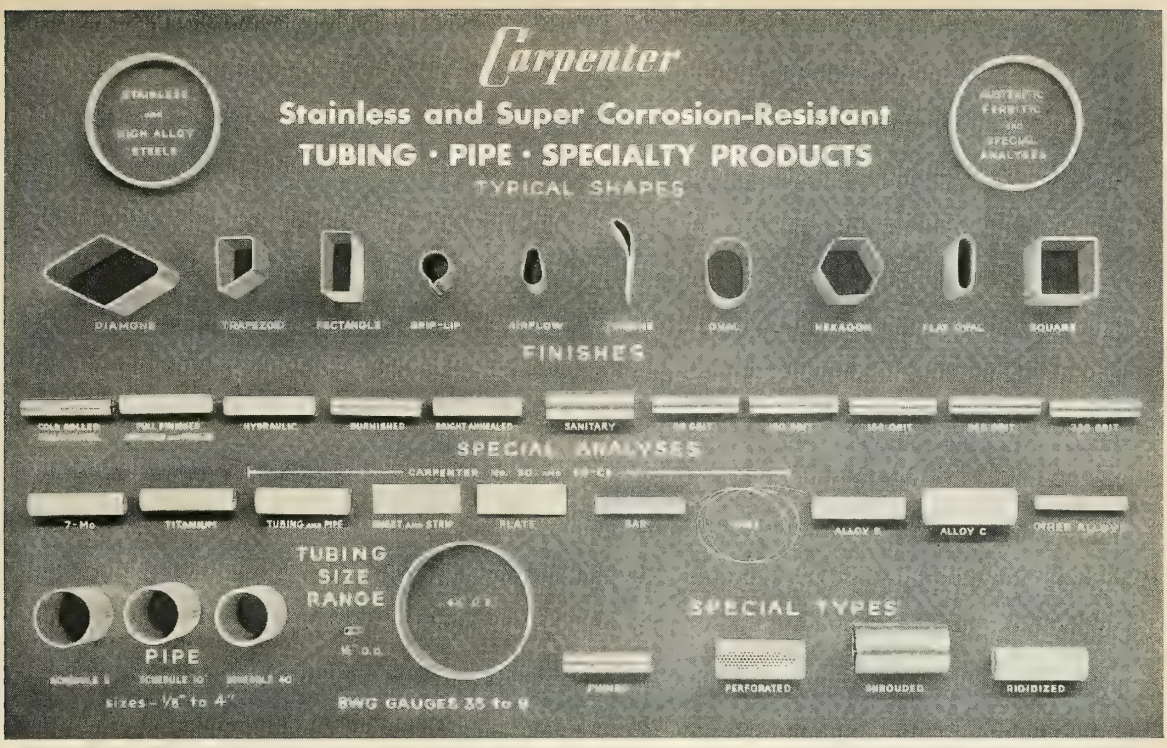
The ideal fuel binder is a low molecular weight carbon-hydrogen compound containing as much oxygen as possible. It should be a low viscosity liquid that can bind together a large amount of solid oxidant. The mixed propellant then should harden rapidly to a thermo-setting solid.

Physicals should be good. Cost and potential availability should be attractive. In reality, however, a number of optimizations have to be made so that physicals, and ease in processing are more important parameters. Of

Figure 1
Solid Propellant Processing

Type			Processing		
Single Base			NC	Solvents Stabilizers	Solvent Removal Extrusion
Double Base	Cordite		NC NG	Solvents Stabilizers	Solvent Removal Extrusion Hot Working Casting
	Ballistite				
	Solventless		NC NG	Plasticizer	Extrusion Hot Working Casting
	Cordite				
	POL Powder		NC DEGN	Plasticizer	Extrusion Hot Working Casting
	Composite		Solid Oxidant Fuel Binder		Extrusion Cold Working Casting

NC: Nitrocellulose
NG: Nitroglycerin
DEGN: Diethylene glycol dinitrate



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AISI TYPES			SUPER CORROSION-RESISTANT TYPES
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304	316	347	Carpenter Stainless No. 20Cb
304L	316Cb	348	Carpenter 7Mo
309	316L	430	Carpenter Alloy B
309S	317	442	Carpenter Alloy C
309SCb	317L	443	Titanium 55 and 70

Other specialty grades in various stages of development are available: Zirconium, Zircalloy II, 19-9 DL, Invar, HiMu80, N-155, Haynes No. 25 (L-605), Hastelloy F and Hastelloy X, Armco 17-7PH, Titanium alloys, A-286 and others.

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the fuel binders in the table, the epoxies and polyurethanes hold promise for future composites.

It is interesting to note that the Soviets are now pushing for large expansion of epoxy resin production in East Germany.

In the homogeneous class, work is now underway at several labs in the synthesis of new, stable molecules to replace nitrocellulose or nitroglycerin. Most of the work seems to be centered around organic nitropolymers. However, improvements in German-developed diethylene glycol dinitrate systems are also taking place.

For composite propellants, the future seems limited to available or readily developed oxidants or fuel binders. Since the oxidant is the heart of a composite system, a breakthrough can only come when a new or ideal oxidant is found.

Summarizing we might say that solid propellant performance is now increasing at a decreasing rate. The big holdback is in available chemicals. If *new kinds* of compounds are developed solid propellants might be pushed into the ultra energy class.

The Ideal Organic Fuel-Binder:

1. A High H/C ratio; low total C; some O; N which can go to N_2; little or no P or S.
2. For smokeless operation no metallics or halogens.
3. Density of 1.0-2.0 g/cm³.
4. Low viscosity, low vapor pressure liquid. High boiling point, low freezing point.
5. Polymerizes with heat (70-200 F) and/or catalyst. Pot life of at least 2 hours. No volatile reaction products liberated. No reaction with or decomposition of oxidizer. Low exotherm in large masses. Total cure time under 24 hours. Low shrinkage on cure.
6. Good binding at low total concencentrations (10-25% of total propellant weight). Gives propellant tensile strength of $>$1,000 psi and compressive strength $>$5,000 psi. Allow cycling of complex grains over temperature range of —80 F to 180 F. Ability to resist moisture. Stable at 250 F for over 1 year.
7. Low cost and high availability.

The Ideal Solid Oxidant:

1. Available oxygen content $>$50%.
2. For smokeless operation no metallics or halogens.
3. Density: 1.5-2.5 g/cm³.
4. Stable solid at room temperature (insensitive to shock).
5. Melting or decomposition point $>$400-700F.
6. Low coefficient of thermal expansion.
7. Non-hygroscopic.
8. Low cost and high availability.

FILLING A NEED...

ing the nineteenth century, the mechanics of fluids branched ne main stem of physical science. Physics concentrated on the oration of the structure of molecules and their components; development of fluid mechanics was guided by the need for erstanding the macroscopic phenomena associated with ships, ines, airplanes, etc. The separation between these disciplines been reflected in the organization of university departments several generations, so that there is little contact between ics and fluid mechanics departments. This lack of contact been reflected in our scientific graduates who typically have trained in one or the other of these disciplines, but almost r in both.

suddenly, however, the country faced an important problem n we had to meet the challenge of rapidly creating an operable continental ballistic missile. The re-entry of this missile into earth's atmosphere was regarded as a very difficult problem; ly because here, for the first time, we faced a scientific prob- involving the mechanics of a fluid closely coupled with im- ant aspects of molecular physics. The Avco Research Lab- ory was created to fill this need. Its senior scientific personnel trained in classical aerodynamics, atomic physics, and ical chemistry, and saw in this interdisciplinary area a unique rtunity to broaden their background and to make creative ributions in a field in which the great advances are still to ade.

laboratory has been successful in supplying vital information h only a year ago was generally held to be obtainable only ostly and time-consuming flight experiments. Our research ess has resulted in a large development responsibility being usted to this company.

interdisciplinary strength we have acquired will enable us to a major role in such problems as the re-entry of manned cles into the atmosphere from satellite orbits, in the creation thermonuclear reactor, and in other fields involving the amics of high temperature gases.

Arthur Kantrowitz

Dr. Arthur Kantrowitz, Director
AVCO RESEARCH LABORATORY
a unit of the

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Dr. Arthur Kantrowitz



Pictured above is our new Research Center now under construction in Wilmington, Massachusetts. Scheduled for completion in early 1958, this ultra-modern laboratory will house the scientific and technical staff of the Avco Research and Advanced Development Division.

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engineering briefs

US-KG Engine Co.s Enter Agreement

The two largest U.S. rocket engine manufacturers have entered into agreements with British firms.

Aerojet-General has signed an agreement with D. Napier, Ltd., which has developed rocket engines for the Ministry of Supply. They produce a variety of engines for both guided missiles and for aircraft applications. The aircraft applications are for auxiliary high altitude speed boost and as a main powerplant. The Napier establishment at Luton is one of Britain's most extensive rocket test installations. Napier Ltd. has been developing and manufacturing rocket engines for six years.

Initial exchange of information with Aerojet will center upon hydrogen peroxide rocket engines. Great Britain has utilized high test peroxide for safe and reliable rocket engines to a much greater extent than the U.S. where peroxide is used for turbopump drives.

Similar negotiations have been entered into between Rolls-Royce, Ltd. and North American Aviation, Inc. (Rocketdyne).

Such negotiations are expected to speed up realization of British defense plans which will be dependent to a large extent upon offensive and defensive guided weapons.

Navy Dedicates Building

Navy has dedicated a $165,000 Bureau of Aeronautics building at El Segundo, Calif., to serve as a center for monitoring research, development and production of aircraft and missiles in eight western states and Hawaii.

R. Adm. John B. Pearson, BuAer general representative, Western Division will direct operation.

Grand Central Hikes Solid Mixing Capacity

Grand Central Rocket Co. will install a large process mixer to increase solid propellant mixing capacity by 2,500 pounds an hour.

The mixer, built by Bramley-Beken of New York, will be installed in a two-story, partly underground structure within the next two months. Mixer is reported to cost about $100,000.

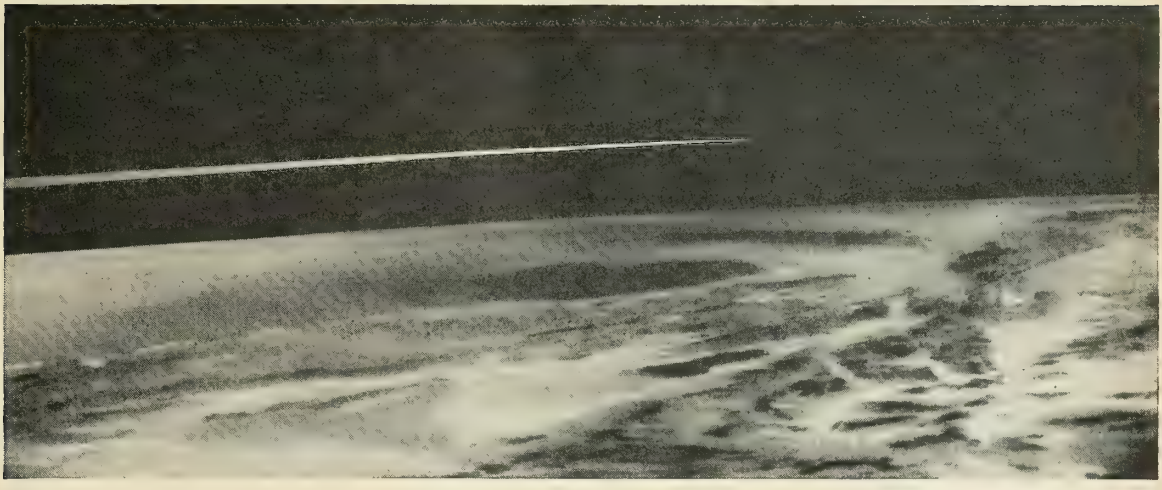
Bullpup Confirmed by Navy

The Navy and Martin finally have announced the new air-to-surface missile—the *Bullpup*. In a speech at Kansas City, Mo. last month, Vice Admiral William V. Davis, Jr., USN,

Career News for Engineers!

Flight Tests are under way on one of America's most important defense projects:

The Navaho Strategic Missile



Artwork based on Official U.S. Navy Photograph

The results are secret—but this much can be told. A test vehicle designated the X-10 has gathered new aerodynamic and electronic information which will help to speed progress on the SM-64 Intercontinental Strategic Guided Missile.

The opportunity—and the privilege—to implement this revolutionary data is yours.



Twenty-eight-year-old Army vet **WILLIAM T. SCHLEICH** was graduated from Georgia Tech in 1952 with a BSAE. He joined North American as a junior engineer the same year. Seven months later Bill was promoted to aerodynamics engineer for the Navaho missile program. He was appointed Supervisor, Stability and Control Unit in October of last year. With the help of North American's Educational Refund Plan, he received his MSAE from USC. Bill and his wife are hi-fi enthusiasts and have a sound system built into their Whittier, California home.

If you accept this challenge you'll be solving tomorrow's problems—today. Here facts are collected fresh daily. If yesterday's yield proves inconclusive you'll approach the problem from a new direction. You'll travel new paths and develop new inventiveness. And you'll be guided to each breakthrough by the world's best-informed missile authorities—your own associates.

One example of the new hardware evolving from this creative engineering effort is a fully transistorized electronic commutator. This instrument increases the information-relaying capabilities of the missile's telemetering system by commutating 27 outputs at speeds of approximately 100 cycles per second. It was developed by the Flight Test Instrumentation Group.

North American's Missile Development Division is a major center of missile activity—and a pioneer in the field. As far back as 1948 its first test instrument vehicle was fired from a launching platform. Today North American has complete weapons system responsibility for the Navaho—and its test program is being conducted at the Air Force's long-range missile proving ground which stretches more than 5000 miles across the Caribbean and far into the South Atlantic.



LYLE C. BJORN has lived aviation all of his life. As a high school boy he built a glider modeled after the Wright Bros.' first flying machine—flew it from ski jumps near his Utah home. He studied engineering at Utah State and earned his BSME degree from the U of Wyoming. Lyle joined North American in 1951 and is now Group Leader, Field Test Operations at the Missile Test Facility, Patrick Air Force Base, Florida. He lives with his wife and three children near Cape Canaveral where he is an active leader in Cub Scouts.

If this sounds like the kind of career-opportunity you've been looking for—write us today. We promise you a working climate that stimulates personal growth and rewards it with responsibility, professional recognition and material benefits limited only by your own ability. Further, you can continue to grow academically with the aid of our Educational Refund Plan—and some of the nation's finest universities are nearby.

Let us know what kind of creative engineering interests you. (Please include highlights of your education and experience).

CONTACT: Mr. R. L. Cunningham, Engineering Personnel Manager, Dept. 495-MAR-6
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Deputy Chief of Naval Operations for Air, outlined the development of the missile and said *Bullpup* is currently undergoing Navy evaluation and will be introduced as a service weapon.

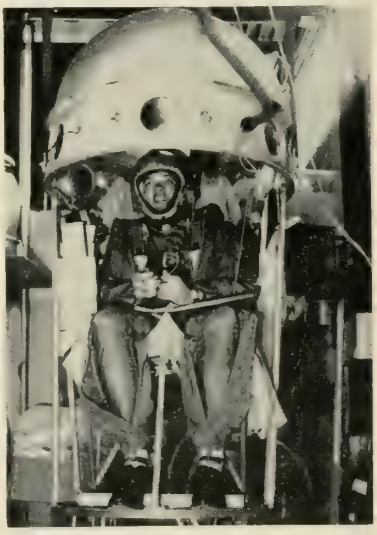
The *Bullpup* is designed to be launched from any position outside the effective range of enemy high-volume ground fire and provide sufficient accuracy to destroy small targets without excessive sorties and expenditures of many of bombs and rockets.

Industry Invests $100 Million for Missiles

Aircraft industry's investment in test and manufacturing facilities for the ballistic missile program is about $100 million, according to Aircraft Industries Association.

AIA president Orval Cook, in an editorial in *Planes*, said manufacturers put 60% of net earnings in expansion last year.

Winzen Balloon Sets Altitude Record



Capt. J. W. Kittinger, Jr. soared to 96,000 feet on June 2nd in a Winzen balloon to set a new record for manned, lighter-than-air flight.

The 28-year-old pilot landed about 80 miles southeast of St. Paul, Minn. after remaining aloft more than two hours.

The flight was part of a series of high altitude tests. Maj. David G. Simon, above, is scheduled to make a 24-hour endurance test at altitudes over 100,000 later this month.

The tests are being carried out by Holloman Air Development Center of Alamagordo, N. M. Kittinger's flight beats the old manned-balloon record of 76,000 feet set last November by nearly 4,000 miles.



Astrionics

By Henry P. Steier

Lockheed's Missile Systems Division has shelved plans to build a "hot" nuclear energy facility building at its Stanford University Industrial Park site in Palo Alto, Calif. Instead a Van deGraaff generator will be installed in the physics laboratory for work on nuclear reactions resulting from acceleration of charged particles.

•

Navy missile men are reportedly interested in the highly accurate low-frequency hyperbolic navigation system developed for USAF by Sperry Gyroscope Co. for position-fixing of ballistic missile launching ships. Stabilization of the launching platform and its exact location are key factors in effective use of such missiles. Reason for Cytac development has been a mystery, especially after AF dropped it and Coast Guard and Navy picked it up with plans to build a Cytac chain along the U.S. east coast. Tactical Air Command, it has been learned, had a tactical mission needing this type of position-fixing but found the system could not fill the bill.

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It appears that the planning program for use of SAGE (Semi-automatic ground environment) calls for control of the *Bomarc* missile as well as piloted aircraft. *Bomarc* will carry an 8-channel data link system for receiving interception data from SAGE centers. There is close similarity between *Bomarc's* data link system and that being readied for piloted aircraft use, with the exception that the latter has a visual display. One of the big contractors for the data link is Motorola, Inc.

•

Latest Pentagon "line" is high cost of electronics. Three military spokesmen in rapid succession recently hit at this matter. At the National Conference on Aeronautical Electronics Lt. Gen. Thomas S. Power, USAF Commander, ARDC said cost of maintaining leadership could reach crisis stage where it affected our civil economy. Rear Adm. Rawson Bennett, USN Naval Research Chief, said unless we force electronics cost down we will someday put the final straw on the taxpayers shoulders. James M. Bridges, Director of Electronics, Office of Asst. Sec. of Defense during AFCEA convention in Washington called attention to skyrocketing costs for weapon system electronics as a critical problem in the defense effort.

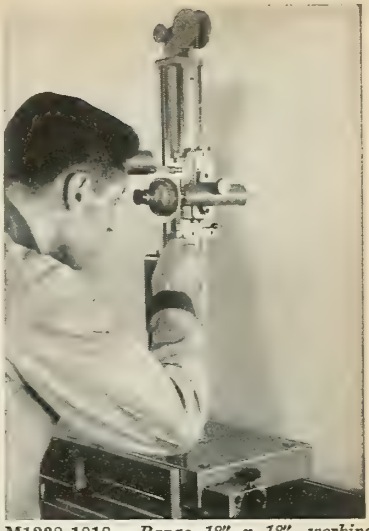
Interesting sidelight on the expenditure problem is Naval Research Laboratory record in this regard. In 1939, NRL received $2-thousand for research. In 1957 the figure is nearing $6-billion.

•

Dr. Bertram D. Thomas, Battelle Institute director, points out that "research and development is not the way to get new ideas." He says the character of the creative process has changed in the last 25-30 years. In the old days curiosity was the motivating factor. Today curiosity has given way to practical application. The character of research people has changed. He's "sure there are no pure scientists left"; there's too much need to earn a living. His parting shot—"The way to get new ideas is to give bigger salaries,"—was highly applauded.

•

Dr. Daniel E. Noble, Motorola's executive vice president, recently asked if his company has given any thought to space communication problems, quickly replied: "I have had some scientific training. Therefore I must first know the problems before I tackle the answers."



M1238-1818 — *Range 18" x 18", working distance 9" to infinity. Reads to 0.001" up to 24" working distance. Protractor ocular reads to 3 minutes of arc. Image is erect.*

Cut inspection time in half

with new Gaertner Coordinate Cathetometers

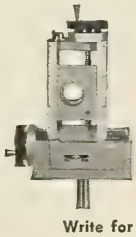
These convenient, reliable optical instruments permit making precise coordinate measurements in a vertical plane. The two dimensions are measured with one setting, object does not have to be rotated. Inspection time is cut in half and resetting errors eliminated.

Versatile Gaertner Coordinate Cathetometers are ideally suited for precision measurements on large objects; also objects or points in recessed, remote, or inaccessible locations. Applications include measuring jet engine sections, complicated castings, printed circuits, bolt holes and bosses on large piece parts, traces on cathode ray tubes, etc.

Because these are optical rather than mechanical measuring instruments, you make non-destructive measurements without contact, distortion, or concern about pressure being applied to the object when making a setting. Instruments available in English or Metric system.

M1236-46— Horizontal range 6", vertical range 4". Reads to 0.0001", working distance 5" to infinity.





M1236-22— Range 2" x 2", reads to 0.0001". Working distance 5" to infinity. Shown with 19 mm mounting rod, and without telemicroscope. Instrument permits precise coordinate movement of other objects such as photo cells, probes, etc., in place of telemicroscope.

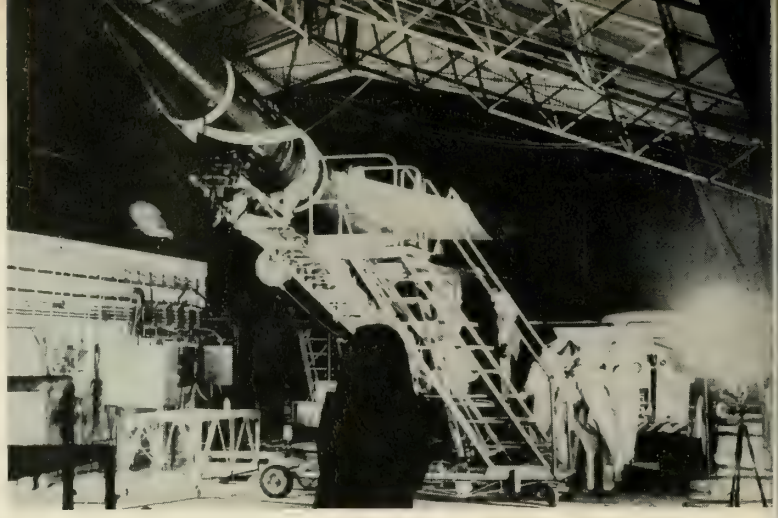
Write for Bulletin 188-53

The Gaertner Scientific Corporation

1258 Wrightwood Ave., Chicago 14, Ill.
Telephone: BUckingham 1-5335

Circle No. 39 on Subscriber Service Card.

The Air Force, after a series of successful firings of the BOMARC XIM-99, has awarded Boeing Airplane Co. a contract for quantity production of the XIM-99 surface-to-air missile. The $7-million contract, initial phase of a larger one, will probably be utilized for the tooling program. Total funds allocated for the larger contract were not disclosed. Initial production plans have slated more than 70 per cent of the program for subcontracting.



According to the Air Force, the latest contract followed superior test results at Patrick Air Force Base. The XIM-99's were launched to seek out and intercept B-17 drones flying over the Atlantic. Individual XIM-99 flights have been carried out since fall of 1952.



BOMARC . . .

Enters Large-Scale Production

BOMARC missiles, with an operating range greater than any missile presently in use in air defense, will provide large perimeters of interception in strategic locations. This area defense role differs from the short-range point defense missiles such as NIKE and TALOS. The BOMARC is about 47 ft. long, has a wing span of 18 ft. 2 in., and weighs 7.5 tons. It is designed to operate at extreme altitudes and supersonic speeds with outstanding range characteristics. Energy required to lift the missile to operating altitude and velocity is provided by rocket and ramjet engines.

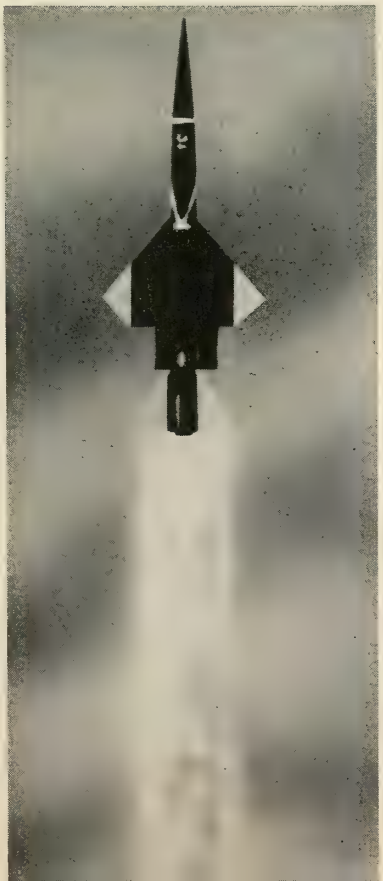




n integral liquid propellant rocket engine esigned and manufactured by Aerojet Gen- ral Corp. provides the boost, while two Marquardt ramjets supply sustainer thrust. OMARC is launched vertically from a com- ination erector and launch pad. The boost ocket provides the impetus necessary to raise he missile to altitude and sufficient velocity or operation of the ramjets. The ramjets, fter rocket burnout, provide the thrust for the cruise phase of the flight.

here are no recovery versions of the OMARC missile, although many designs ave been proposed. The advantages of a ecovery system have not appeared equal to he disadvantages imposed upon the missile levelopment. Instead, a system was devised or installing the guidance package of the BOMARC in the nose of piloted aircraft, such as the B-57.

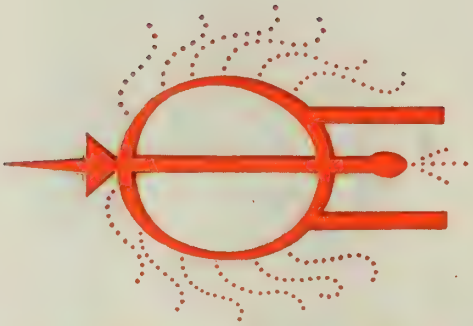




The recent decision to use existing production facilities in Seattle for the BOMARC production program brought to a climax the search for a location, which had extended over a period of several months.

Boeing presently holds additional contracts for the experimental production model XIM-99 and the service test model YIM-99. The first production missiles will be assembled at the Seattle division's Plant I, where the experimental models are assembled.





صفة بيضة تخرج وتخرق

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Nuclear Radiation . . . New Challenge for Transistor Makers

Greater Exchange of Information Needed to Speed Future Missile Development

by Henry P. Steier

ONE OF THE MOST difficult prospects in store for astrionics designers is choice of components for a nuclear environment. A key component in the designs will be semiconductor devices. Their operation basically depends on a highly uniform crystalline structure. Such structures are susceptible to radiation damage.

Semiconductor devices are already making history through their utility as size-reducing and power-drain-reducing control components in the ever more complex astrionics gear being built.

Although the status of semiconductors today represents what Dr. Daniel E. Noble of Motorola, Inc., recently called "the first revolution in electronics," their use in future nuclear powered missiles, spacecraft, manned and unmanned aircraft and tactical environments will be even more wide-scale in some weapons.

The environments to which semiconductors will be subjected might be broken down into three classes: that near a controlled nuclear reactor for a propulsion system; near an uncontrolled nuclear reaction produced by bombs or missile warheads; cosmic radiation in the outer reaches of space.

The importance of knowing the effects of radiation on materials cannot be overemphasized and has been under study for some time. But in the final analysis material effects are the lowest common denominator in the interpretation of effects on astrionics components and systems.

Although several investigators have reported within the past six years that germanium and silicon are sensitive to nuclear bombardment, the information gave little help to semiconductor devices or application engineers.

Early in 1957 the Defense Department gave recognition to the urgent need for a further exchange of information in this field and sponsored an unclassified symposium on nuclear radiation effects on semiconductor devices and materials.

Sponsorship was under the auspices of the Office of Asst. Sec. of Defense, R&D, Advisory Group on Electron Tubes. A surprising revelation to the participants was that so much work is going on. It is being carried out under Air Force, Signal Corp., Atomic Energy Commission, and industry sponsorship.

Investigation of the radiation effects on semiconductors was reported by: Oak Ridge National Laboratory; Radio Corp. of America; Purdue University; Boeing Airplane Co.; Glenco Corp.; Cook Electric Co.; Diamond Ordnance Fuze Laboratories; North American Aviation; Jet Propulsion Laboratory; National Bureau of Standards; Bell Telephone Laboratories; Hughes Aircraft Co.; Haller, Raymond and Brown, Inc.

Work being done by these organ-

Table 1

Degree of Sensitivity	Transistor Type	Kind	Material	Manufacture Method	Manufacturer	Case Filling	Parameter Most Sensitive
EXTREME	2N43	PNP	Ge	Alloyed	GE	Grease	I_{co}, V_b
	904, 905	NPN	Si	Grown	TI	Gas	I_{co}
	XH5	PNP	Ge	Alloyed	MH	Gas	I_{co}
MODERATE	926	NPN	Si	Grown diffused	TI	Gas	I_{co}
	501	PNP	Ge	Grown diffused	TI	Grease	I_{co}
	2N27	NPN	Ge	Grown	WE	Varnish	..
	SB-100	PNP	Ge	Surface Barrier	Philco	Grease	..
	2N139	PNP	Ge	Alloyed	RCA	Grease	I_{co}
	2N43	PNP	Ge	Alloyed	Transitron	Gas	..
	2N99	NPN	Ge	Grown	GP	Red Paint on Junction	I_{co}
	2N260A	PNP	Si	Alloyed	Clevite	Grease	..
	2N167	NPN	Ge	Rate Grown	GE		I_{co}
LOW	2N198	PNP	Ge	Alloyed	Transitron	Gas	..
	CK790	PNP	Si	Alloyed	Raytheon	Grease	..
	2N34	PNP	Ge	Alloyed	Sylvania	Gas	..
	2N35	NPN	Ge	Alloyed	Sylvania	Gas	..
	2N109	PNP	Ge	Alloyed	RCA	Grease	..
	156	NPN	Ge	Alloyed	RCA	.....	..
	951, 952, 953	NPN	Si	Grown	TI	Glit	..
	L6101	NPN	Si	Surface alloy	Philco	Grease	..

Boeing's Pilotless Aircraft Division found these relative differences in sensitivity of transistors to gamma induced transient effects. Gamma flux was approximately 2 x 10° R/hr.

izations has been under way for about two years, and the newness of radiation investigations in this field is revealed by sometimes divergent approaches to the studies.

In fields as complex and secret as nuclear energy, and as new as semiconductor technology, the effects of limited background information and decentralized research programming are quick to show up.

Test results on radiation damage to semiconductors as revealed thus far, show somewhat contradictory results and the data is not always comparable, or applicable to practical use.

It is generally agreed that nuclear effects of concern to semiconductors are fast neutrons and gamma rays. Protection of semiconductors against the effects of slow neutrons is relatively easy to achieve with shielding.

Such shields as boron carbide-aluminum alloy are light in weight and relatively inexpensive when compared with water, concrete and the so-called "rate earths" fast neutron moderators.

In the case of nuclear powered aircraft and missiles, distance between the reactor and astrionics gear would help radiation reduction. Intensity of a radiation source is inversely proportional to the square of the distance from the source. Radiation from a source with a diameter of two feet would be down to 0.1 per cent at a distance of 60 feet from the reactor.

Measurements made by early investigators on germanium and silicon reaction to nuclear radiation were concentrated on the majority (resistivity and Hall coefficient) carrier density properties.

Changes in these properties were attributed to imperfections produced in the crystal structure of the semiconductors. The imperfections could be caused by fast neutrons, gamma rays or recoil nuclei. Or the atoms could be transmitted by slow neutrons.

Much work which had been done was on static characteristics. In a recent study by G. L. Keister and H. V. Stewart, Boeing Airplane Co., they noted that only limited information was available on the minority carriers.

The lack of minority information, it was felt, was handicapping information important to the fabrication of acceptable nuclear radiation resistant semiconductor devices.

Under a contract sponsored by the AF Wright Air Development Center, Boeing's Pilotless Aircraft division ran a test program on electrical characteristics of the transistor while the device was being irradiated.

In any application of these devices it is the dynamic situation which is of first importance. To perform its job the circuit must be operating correctly.

Boeing performed its tests with the Materials Testing Reactor Gamma Facility at Scoville, Idaho. This facility uses spent fuel elements from the Materials Testing Reactor (MTR) there, and produces a full fission product gamma spectrum. Gamma flux was about 2 x 10^6 Roentgens per hour.

Static and dynamic tests were made with gamma radiation only, to permit separate observation of defects from gamma and neutron irradiations. Other tests were made in the MTR for neutron effects.

Neutron flux was about 5 x 10^9 neutrons per square centimeter per second (nv). Total neutron dose was measured in terms of neutrons per square centimeter (nvt)[6].

The *nvt* unit used in nuclear dosimetry is an abbreviation for the number of neutrons per cubic centimeter multiplied by their velocity in cm per second and the time in seconds.

A cadmium shield 0.025 inches thick was used to moderate the slow neutrons in most tests. Transistor characteristics chosen for test were those that would define the operating region of the device. These were: collector leakage current—I_{co}; current gain —beta; and the breakdown or punch-through voltage.

Tests were also run on junction heating effects with gamma radiation. A thermocouple was placed within the transistor case on the junction and the difference in ambient and junction temperature measured. The difference was less than 10 degrees C for a gamma flux of 2 x 10^6 Roentgen per hour.

The gamma radiation resulted in a number of transient changes. Most sensitive in this regard were I_{co}; Beta and floating potential. I_{co} increased with time until removal from the flux in some cases. In others it reached a saturation point. Floating potential varied in the same manner.

After removal from the radiation the transient effects disappeared quickly. The effects, however, varied widely between different transistors.

Examination of the types tested and their construction characteristics showed no particular relationship between construction and sensitivity to transient effects.

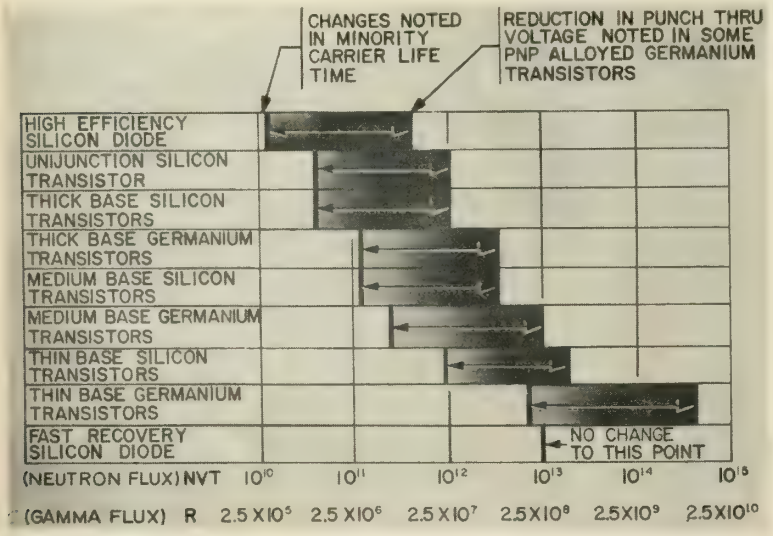
Another effect of radiation was induction of photovoltaic voltages in the pn junction. For a gamma flux of 2 x 10^6 R/hr. this was 10-50 volts. It was independent of circiut loading.

Noise was another effect. Noise level increased to about 25 db. This could be a big problem for applications using low signal levels. The noise disappeared after the transistor was removed from the flux.

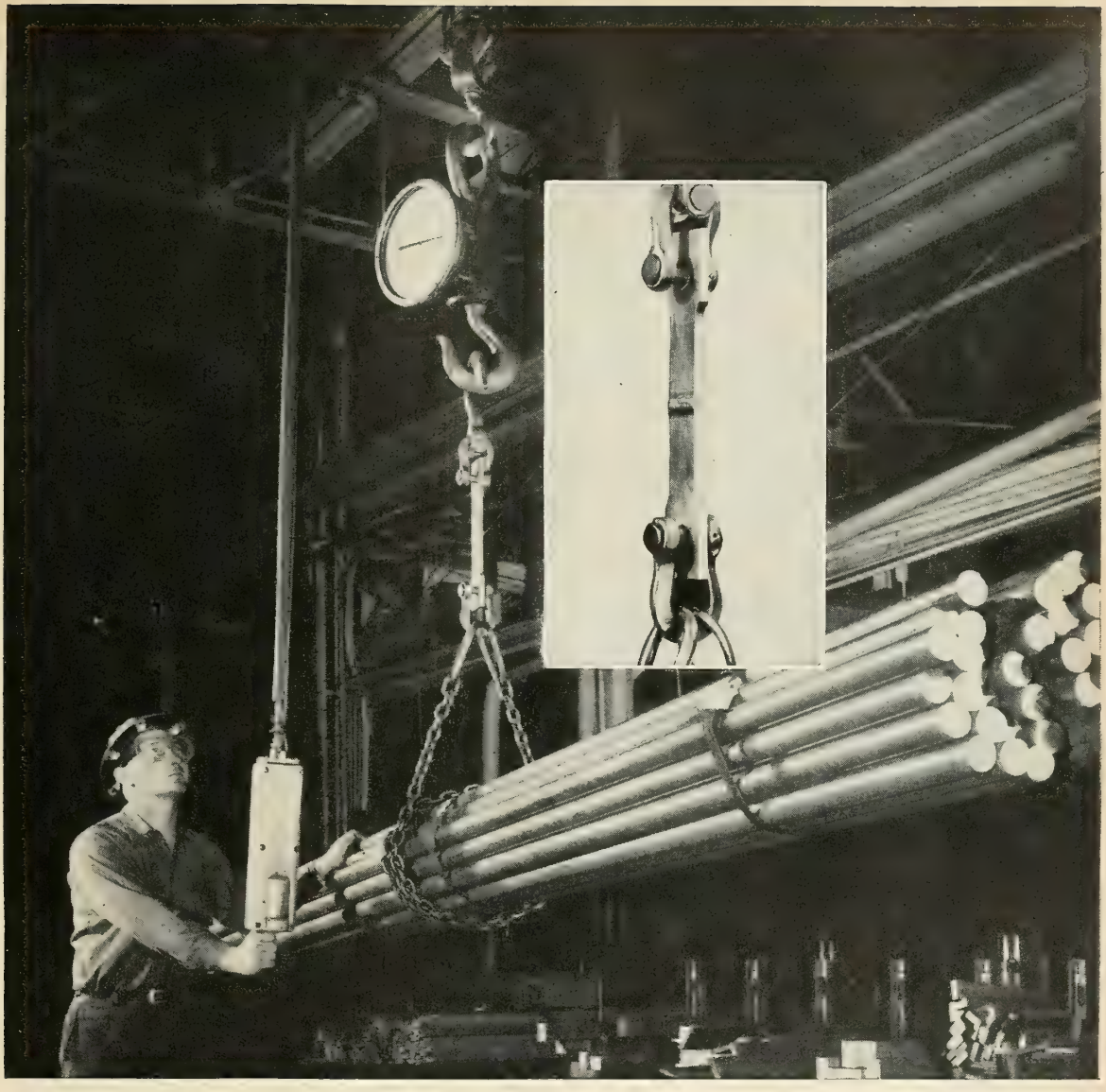
Boeing concludes that high frequency, thin based, transistors are the most resistant to nuclear radiation, and the germanium types more resistant than equivalent silicon types.

Reports generally indicate that gamma and fast neutron radiation gamma fluxes of from 10^6 to 10^9 R/hr. and neutron fluxes of 10^{11} to 10^{13} nvt cause changes in some characteristics.

Gamma flux damage is often transient and anneals out. Neutron flux



Relative sensitivity of selected semiconductor devices to neutron and gamma induced permanent damage as determined by Boeing. Light-shaded areas indicate beginning of permanent changes. As area becomes darker changes become sufficient to affect operation in more sensitive circuit applications.



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damage is more permanent and changes remain after extended storage.

In the case of silicon semiconductors, it appears they are only subject to damage in characteristics depending on the minority carrier lifetime (current gain).

The new environment in which transistorized astrionics must operate presents a challenge that must be faced as rapidly as possible by researchers, manufacturers and users.

The problems are compounded by many factors. Each day more semiconductor types are put on the market. Many of them have similar characteristics but are made by much different methods and combinations of different materials.

Boeing proposes that more attention be paid to the method of manufacture and to establishing a new specification indicating a semiconductor's susceptibility to radiation.

The parameters of radiation present another challenging task for specification. The type of radiation, the spectrum it covers, integrated flux values, etc. are but some of these.

These factors are of major importance in comparing work on determining radiation damage. The flux values are not meaningful unless spectral information is included, for instance.

Boeing has suggested that punch-through voltage of a pnp type semiconductor might be used as a radiation dosimeter. This would be a true integration of spectral difference effects and germanium cross section variations. Dosimeters of this type would be inexpensive and allow accurate checks of dose or dose effects.

It may be found that the rate of radiation is very important in determining total damage. This factor would be very important in weapon systems concept planning.

There is a multitude of environmental conditions to be anticipated. These would be contingent upon the mission of a weapon. In a conflict near-misses can be expected. These might produce nuclear clouds through which another weapon must pass.

If the missile must penetrate this cloud, radiation conditions in terms of intensity and time would be much different than under the controlled conditions in a nuclear powered vehicle.

Whole new families of transistors designed for various nuclear conditions are likely to appear in time. One of these conditions might be the effects of cosmic rays.

Jet propulsion Laboratory reports that particles with 10^7 electron volts energy exist at 100,000 feet altitude. If a space craft were at altitude for a long time, say one year, cosmic radiation might be a matter to contend with.

At this time manufacturers do not have much information to go on for their radiation resistant designs. But there does appear hope for eliminating the possibility of a complete lack of suitable semiconductors for certain applications if the limited information available today is put to use soon.

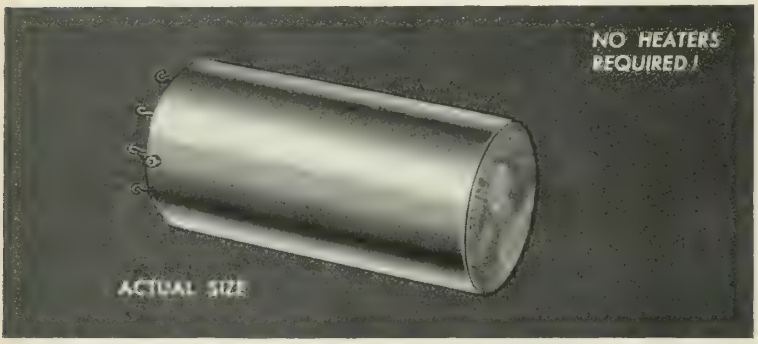
This could result in production of limited numbers of semiconductor devices to meet immediate needs. And, these might be at least a few orders of magnitude more resistant to radiation than those we have today.

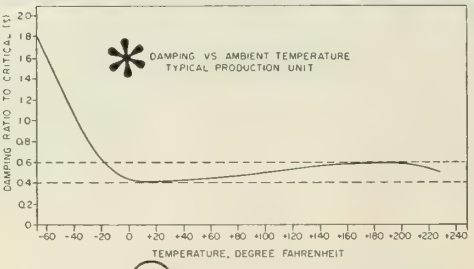
The systems concept planners of the future will have to dig much deeper into the electronics boxes than has been previously done. The transistor is only one of hundreds of items and materials that present radiation problems in an astrionics circuit.

To design black-boxes that have mission capability in all the various nuclear environments imaginable is going to be a science in itself.★

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Studying Ballistic Missile Flight Behavior Requires Careful Pre-Flight Preparations

By Charles T. N. Paludan

Army Ballistic Missile Agency

ONE OF THE MOST vital design parameters of a successful missile is temperature. In big high-speed missiles, temperature measurements in the different missile areas present a number of novel problems. These were solved for the *Redstone* ballistic missile largely by the use of conventional, available equipment. What new devices had to be designed and the special techniques developed provide a valuable basis for the instrumentation of subsequent larger, longer-range missiles.

From the initial development of the *Redstone* missile an extensive temerature measuring program was desired. These measurements were to be made during flight and telemetered back to earth.

Four measurements on the missile were required. They were: (1) surface temperature from aerodynamic heating; (2) structural temperature resulting from aerodynamic heating and from rocket engine exhaust; (3) propellant temperature and (4) ambient air temperature at various critical points within the missile.

Of the several types of gauges available, three have been used to date: thermocouples, resistance thermometers and thermistors. Thermocouples were used for those measurements where the temperature change would produce output suitable for use in the amplifier-telemeter system available.

Where low-span surface measurements were required, resistance thermometers were used. Thermistors were used for very low span measurements of the probe type.

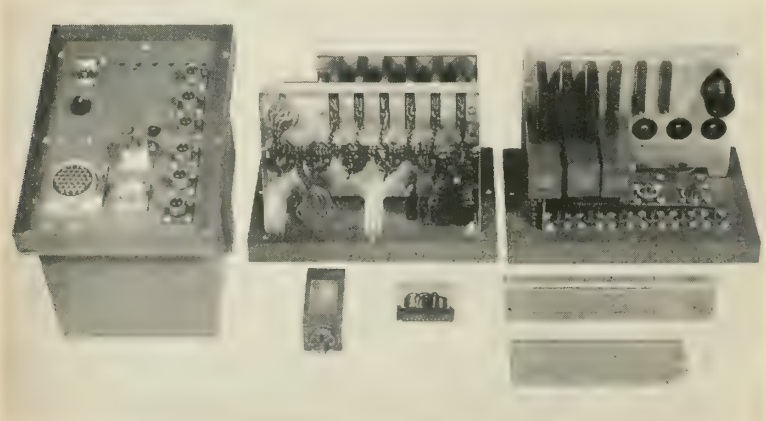
Early in the development of the *Redstone's* temperature measuring equipment, no amplifier was available with sufficient stability under the severe environmental conditions encountered in a missile of *Redstone's* nature. Therefore it was not possible at that time to use thermocouples.

It was, however, possible to obtain large outputs from comparatively small spans of temperature change by using resistance thermometers and thermistors operating into deflection-type Wheatstone bridge circuits fed by high DC voltage. Besides ruling out thermocouples, this system had the additional disadvantage of requiring either several high voltage supplies or running the risk of one gauge's malfunction ruining the entire temperature measuring program of a given missile.

Furthermore, resistance thermometers were not readily available for measuring temperatures above 900°C because of the insulation resistance loss above that temperature. Because of the high stability of the nonamplified system, however, it continues to be used for temperature measurements of the liquid propellants power supplies (mercury cells).

Within the past year or two, second-harmonic-type magnetic DC amplifiers have become available with sufficient stability for use in the temperature measuring program. A large number of temperature measurements were required. Therefore, a universal system was evolved for use with any of the gauge types previously mentioned.

This system included a method of selecting gauge type, range, and span by means of a small plug-in unit. A stable 5-volt DC supply was available in the missile and was used in conjunction with deflection Wheatstone bridge circuits to give a small output from the resistance thermometers and thermistors. This small output was amplified in the same manner as a thermocouple



How the REDSTONE minds its measurements. Above is a typical signal adapter for converting inflight measurements into telemetry signals. Shown in the picture are the various plugs for gauge input, power supply inputs, outputs to go to the telemetering system and the large plug for pre-flight check-out service. These components can be spotted about the missile as space is available.

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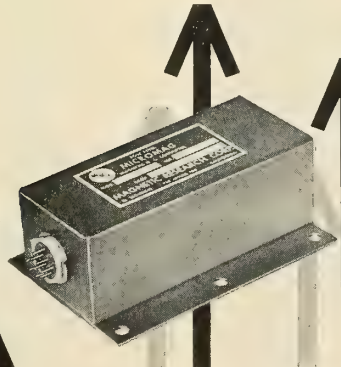
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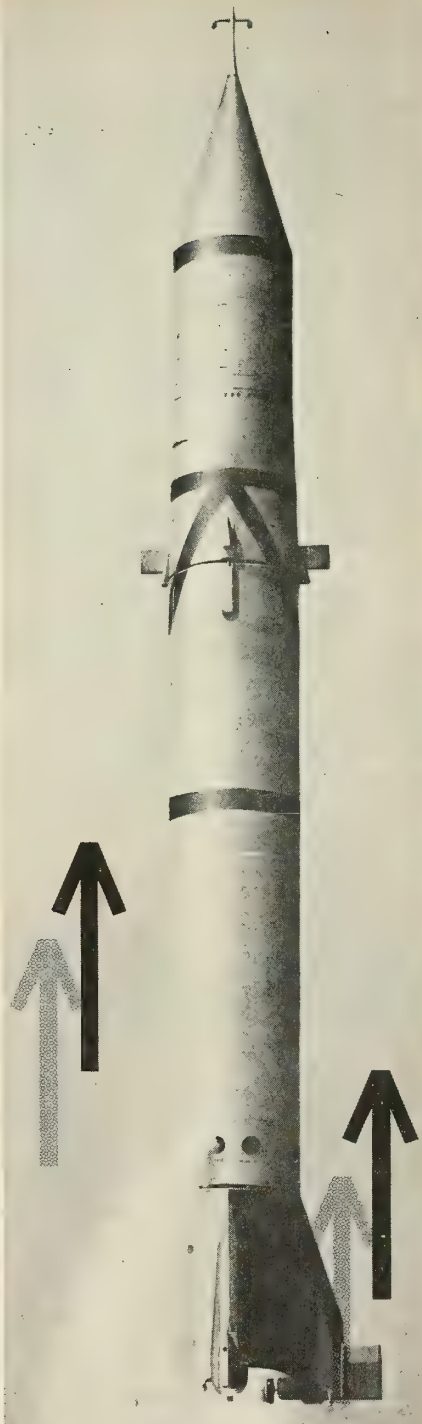
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output by the magnetic amplifier.

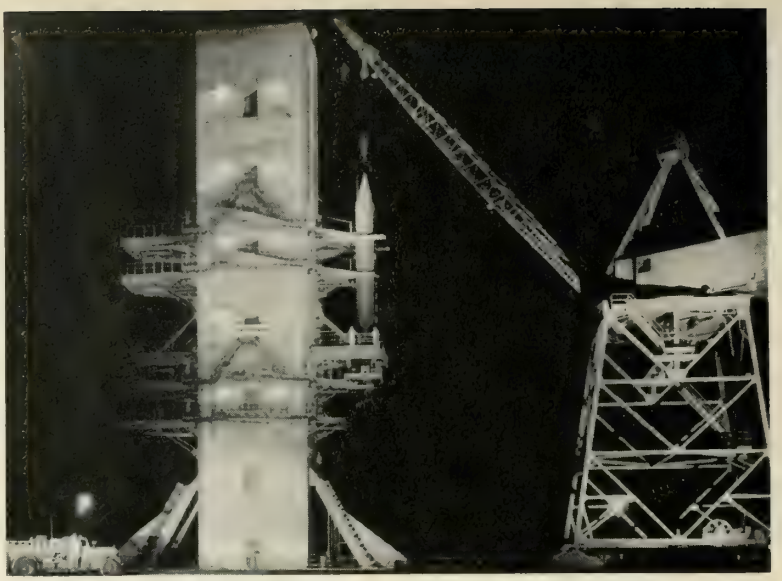
In the *Redstone* missile circuitry used to convert end-organ output to output suitable for telemetering is commonly called an "adapter."

It was very important that measurements operate as satisfactorily as possible because of the non-recoverable nature of a ballistic missile. The complexity of necessary checkout actions at the time of missile fabrication and at the launching site made a semi-automatic check-out of measuring equipment imperative.

This check-out had to warn of malfunction or misadjustment in either the sensing gauge, the adapter, or missile wiring. Accordingly, the adapter circuitry included provision for a fixed known output which could be inserted through the entire system by remote control.

For all measurements an output was recorded on a strip-chart recorder and afterwards compared with laboratory data to prove proper function. Improper function would have called for readjustment, repair or replacement of equipment.

As may be seen in Fig. 1, a typical adapter included provision for six measurements. In many cases a number of adapters would be installed in various parts of the missile. The photograph shows the various plugs for gauge input power supply inputs, outputs to go to the telemetering system, and the large plug for a pre-flight check-out device. The back view reveals several magnetic amplifiers, the plug-in units for determining gauge type and range, and the wiring.



REDSTONE, predecessor to JUPITER, just before static test firing at Army's Redstone Arsenal, Huntsville, Ala.

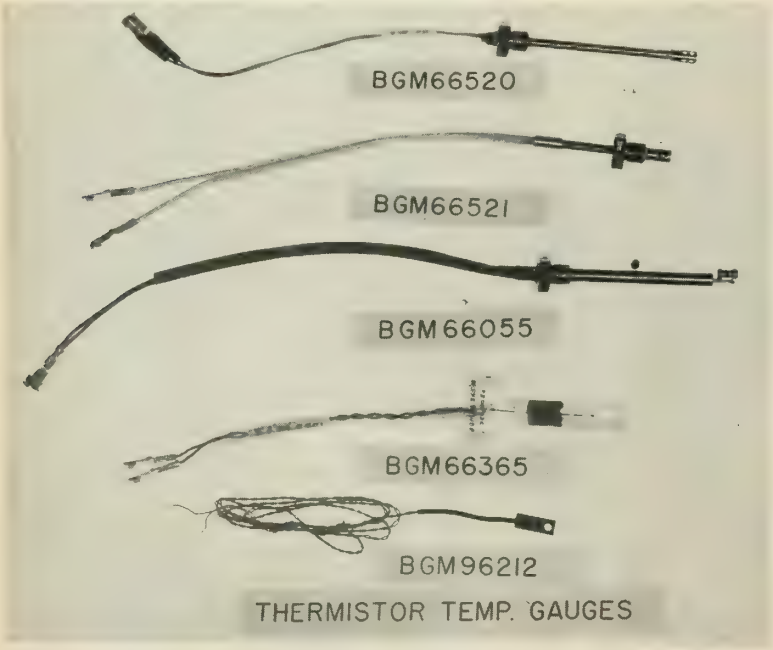
The design of the adapter was dictated by three main requirements: (1) It must withstand severe shock and vibration conditions; (2) It must be easily accessible so that mass production techniques are applicable; (3) The finished enclosed adapter must be protected from injury or misadjustment because of rough handling during shipment, or after installation.

Before delivery to the missile, each completed adapter was calibrated in the laboratory, the missile conditions being simulated as closely as possible. A calibration curve was supplied for each measurement.

The design of all end-organs, some of which are shown in Fig. 2, was dictated by the same conditions mentioned for the adapter. In addition they were individually calibrated in the laboratory by means of water baths, ovens and in the case of the liquid oxygen gauge, a temperature-controlled liquid oxygen bath. Each type of gauge was studied in regard to time response, accuracy and reliability.

In particular regard to thermocouple measurements, a special cold-junction compensation device was developed which eliminated the need for long thermocouple leads and ice baths or ovens. One such device, referred to as a "zone box," was incorporated with each thermocouple. It used a resistance thermometer to sense the "cold" junction temperature, drew power from a mercury cell and applied a correction to the output so that the cold junction seemed to remain constant at a fixed artificial temperature. In addition the zone box was adjustable so that the "cold" junction could be set at any temperature within certain limits.

The measuring system described should not be considered the final design. However, the large number of temperature measurements have made a "design freeze" necessary in order to mass-produce hardware. Improvements and modifications are certain.★



Above is an array of typical thermistor temperature gauges for measuring inflight conditions during test firing of the REDSTONE.

MOTOROLA RADAR PICKETS IN THE "DEW-LINE" FENCE



Stretching 3,000 miles across the Arctic, special Motorola radar systems stand alert, ready to sound a warning at the first indication of an air attack over the polar cap.

The urgency of this distant early warning system called for a "crash" program for both development and production. Working in turn with the Lincoln Laboratories at M.I.T., Bell Telephone Laboratories, and the Western Electric Company, Inc., Motorola engineers came through with radar systems for the complete line within a 14-month period.

This is only one example of the military electronic equipment being developed and produced by Motorola for the varied military applications.

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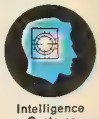

Solid State Physics


Missile Systems and Components


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Underwater Instrumentation

Problems of Missiles That Live Beneath the Oceans Require a New and Different Look at Instrumentation

WITH THE ADVENT of submarines that do 60 knots or better, Fleet Ballistic Missiles that can be fired from underwater to deliver a devestating thermonuclear blow in the heart of the Soviet land mass and torpedoes that top 150 knots, the undersea ocean becomes a military environment of prime importance.

The need to know all there is to know about it gains a high priority. Not only must all the constants of its state be known for any particular moment, but these must be charted, if possible, as they change day-by-day and hour-by-hour.

As research rockets and balloons are sent into the upper air to learn about the fringes of outer space, so must instrument assemblies be sent into the deepest ocean depths to probe and record the darkness man knows least about. Underwater instrumentation, which for years has been the oceanographers more-or-less private tool, now becomes an esential military technology.

Perhaps the most critical factor in undersea warfare is sound: its attenuation at different frequencies and its refraction with changing water density. These properties are affected by temperature, pressure, salinity and the type and amount of biological life present. Some of these are in turn dependent on the penetrability of light, both visible and invisible, the tides, ocean currents, atmospheric conditions, proximity of fresh water sources, etc.

Underwater instrumentation is necessary to measure these and other characteristics. In the operational military field, new requirements are encountered—such as a passive listening device that can hear and identify a noise source several hundred miles away or a "smelling" device that can pick up and track a ship's wake.

The following takes a brief look at some of the problems encountered in underwater instrumentation and how they are solved. It is not so much concerned with detailing specific solutions to specific problems as it is in generalizing approaches to this unusual missile environment.

Oceanographic instruments may be conveniently divided into two major groups: Those which are designed to resist pressure or are pressure protected, and those which are in pressure equilibrium at the depth in which they operate. Generally these instruments are fluid filled. In the latter class of instruments it is obvious that all internal components, condensers, resistors, and electronic tubes must be designed to withstand the pressures at the operating depths.

In general design limitations, 15,000 psi is a working maximum. Where light sources are required, a standard flash-light lamp, Type G 3½ bulb, will withstand pressures of the order of 20,000 psi.

Sub-miniature radio tubes using the T 3½ envelope withstand pressures in excess of 15,000 psi. It should be pointed out, however, that not all makes of sub-miniature tubes are suitable. In normal operation the electron tubes and components are directly immersed in oil, frequently silicone oils where the dilectric characteristics are important. Cheaper oil such as Shell deodorized spray base, which is a highly refined, sulphur-free kerosene, is used.

DC motors, AC motors, relays and most moving contact electronic components will operate quite satisfactorily in this oil filled high pressure environment. In fact, oil filled vibrator type inverters have been used successfully. One of the useful by-products of this strange environment is the fact that under high pressure it is impossible to have any contact arcing.

Telemetering is done using standard RDB telemetering channels for subcarriers. The signals may either come up over single or multiple conductors and often use the sea as a return circuit. The approach at the Scripps Institution of Oceanography is toward simultaneous, continuous telemetering using FM and the RDB subcarriers and recording on deck or ashore using function plotters and magnetic tape.

Magnetic tape has many advantages. Perhaps most important is that it makes possible detailed analysis on return to the laboratory along with automatic data processing.

One example of underwater instrumentation is the telebathyphotometer, telemetering bathyphotometer. It is essentially a deep sea photometer. This particular instrument is controlled from the surface and telemeters all information back over a single wire circuit using a sea return. The instrument is relatively slow in response due to the fact that the functions being measured are not changing at a very high rate.

Its telemetering circuit is DC and is independent of external circuit voltages and polarization. The design depth of this particular instrument is approximately ½ mile. The major depth limitations are due to the somewhat uncertain strength of the pure crystaline sapphire window. The temperature sensing element is not designed for a high speed of response as this is not a fundamental requirement.

In order to facilitate operations in a high relative humidity when the case must be opened, the subassemblies which are susceptible to moisture, are unitized and are each hermetically sealed, having their cases flushed with anhydrous nitrogen. This makes it possible to operate under rather adverse circumstances when using high impedance circuits. On completion of assembly in the field or after a change of batteries the entire instrument is flushed out or purged with the anhydrous nitrogen.★

electronics briefs

Sperry Gyroscope Reveals New Plant

Sperry Gyroscope Co. has revealed that it is operating a completely new facility for producing super-precise gyroscopes needed for long range missiles, aircraft and missile-launching Naval vessels.

Recently the identity of one of the Sperry inertial platform projects was revealed when the SINS (Ship's Inertial Navigation System) was announced. Originally the term meant Submarine Inertial Navigation System.

According to F. D. Braddon, chief engineer, Sperry Marine Division, new and formidable navigation problems are encountered by atomic submarines capable of "sustained" submergence.

With new tactical uses planned for the submarines, present standards of navigation are unsatisfactory, Braddon said. One new use is believed to be underwater missile launching.

Such launching would require exact information on heading, roll, pitch and position. An added requirement, not imposed on airborne systems would be the requirement for operation of the inertial platform for periods of months.

Universal Transistor Takes Larger Plant

A 500% sales increase in two years—with even faster growth anticipated—has resulted in the acquisition of a new air-conditioned 12,500 square foot plant by Universal Transistor Products Corp. at Westbury, Long Island, N. Y.

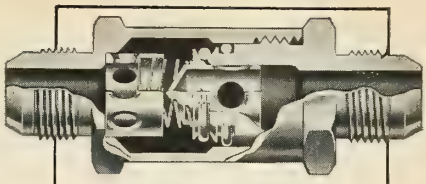
Universal Transistor's sales and advertising offices have also been expanded to one and one-half full floors at 143 E. 49th St., New York City.

Universal Transistor manufactures commercial and military transistorized power supplies ranging from low-power consuming units for radios and radiation detectors to high power units for rockets, missiles, microwave stoves and electronic flash units.

Honeywell Aero's Employment up 1500

The Aeronautical Division of Minneapolis Honeywell Inc. now employs 6500 people, a gain of 1500 in 12 months. The seven-year old division attributes this gain largely to increased work on missiles and automatic flight control systems.

one drop of leakage can destroy a $1,000,000.00 missile!



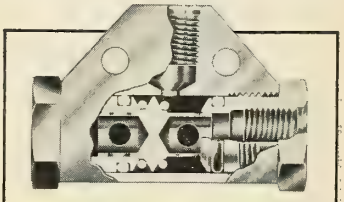
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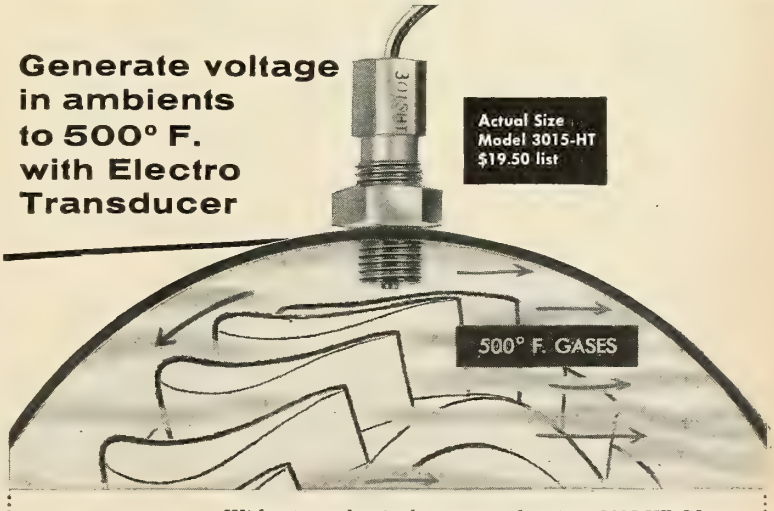
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ANNOUNCES

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Space Medicine

by Hubertus Strughold, M.D., PhD.

A fifty-five page report is now available on the presentations at the Summary Session of the Astronautics Symposium held in San Diego, California, on February 18-20, 1957 under the sponsorship of the U.S. Air Force Office of Scientific Research and the Convair Division of General Dynamics Corporation. This publication also contains a summary of the Human Factors Panel, which dealt essentially with radiation hazards, human enigneering and psychological problems in closed systems, human logistics in satellite operations, and space law.

•

On May 10th, at Brooks Air Force Base near San Antonio, Tex., a formal groundbreaking ceremony was held for the new headquarters of the USAF School of Aviation Medicine. Among the many officials attending were Congressman Paul Kilday of Texas; Major General Dan C. Ogle, Surgeon General of the Air Force; and Major General Dean C. Strother, Commander of Air University. The ceremony was conducted by Major General Otis O. Benson, Jr., Commandant of the School, which now is at Randolph Air Force Base, Tex. The mission of the new school will include research and teaching in space medicine.

•

The Aero Medical Association held its 28th annual meeting on May 6-8, 1957 in Denver, Colo., under the direction of its president Jan H. Tillish of Rochester, Minn. The meeting was attended by more than 1,100 persons. A special session of the Space Medicine Branch was held on the last day. The following topics were presented: Cosmic ray dosage during the giant solar flare of Feb. 23, 1956; medical aspects of the U.S. Navy stratolab program; sealed cabin atmospheres; experimentation in the space cabin simulator; weightlessness in space operations and in water; and the visibility of artificial satellites.

On the afternoon of the same day, a symposium on space travel was conducted by Col. Paul A. Campbell, USAF (MC). This session presented views on space travel, as seen by the propulsion engineer, the astronomer, the astrophysicist, and the test pilot. In addition, problems of instrumentation and survival, the space travel implications of the Vanguard Project, and the possibility of a habitable extraterrestrial environment that could be reached from the Earth were discussed. The Symposium was attended by over a thousand people. The papers from both sessions will be published in the Journal of Aviation Medicine.

•

A series of thirteen half-hour educational television programs on space medicine, under the title, "Doctors in Space" is now nearing completion at the University of Houston, Texas. These programs, financed by the Ford Foundation, will be distributed by the National Education Television Center of Ann Arbor, Mich. Some two dozen experts in space medicine and its related fields, including rocket engineers, test pilots, and Air Force and Navy specialists, have taken part in the discussions, which cover the entire range of human factors involved in space operations. The scripts have been prepared by Mr. Green Peyton, Chief of Information Services at the School of Aviation Medicine.

•

A Symposium will be conducted by the writer of this column on "Problems Common to the Fields of Astronomy and Biology," June 17-19 at a joint meeting of the International Mars Committee and the Astronomical Society of the Pacific.

The topics include a "Survey on Astrobiology," "Spectroscopic Evidence of Vegetation on Mars," "The Behavior of Micro-Organisms Under Mars-Simulated Environmental Conditions," "Balloon Capabilities for Astronomical Observations," and "Application of Recent Advances in Physiological Optics to Astronomy."



NEW ROCKET POWER

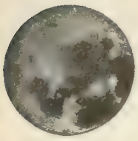
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Missile Miscellany

Is AF rushing Thor into production in hopes it will be too late and too costly to give the nod to Jupiter even if Army missile proves best? That question from a top Army missile man who hopes AF in evaluating Jupiter won't "make the rules after the game has been played" and thus guarantee pro-Thor decision. He also thinks selection should be made solely on missile's merits—its ability to go accurately from point A to point B whenever button is pushed. Sounds logical.

Meanwhile, whole business may become academic as trading of Jupiter and Thor knowhow speeds up (Thor may adopt Jupiter thrust control guidance: Jupiter has incorporated Thor anti-slosh devices in fuel tanks) and the two controversial IRBM's take on a certain similarity. . . . And while Patrick wags have tagged Thor the civil service missile "because it won't work and you can't fire it," Jupiter—the first IRBM to break the record for the over-1000-mile dash—has solved its (and Thor's) gas generator exhaust problems. These stemmed from shift from peroxide to hot drive for auxilliary power turbine. Backwash burned out directional controls on main engine.

In the fantastic tales department, this page hears on what should be good authority, of 12 eight-or-nine-foot diameter spheres with three-eighth's inch thick stainless steel skins being rushed to Patrick AFB "to be crammed with instruments and fired before first Vanguard launching." Interesting, if true, for these toys tip the scales at a ton apiece empty!

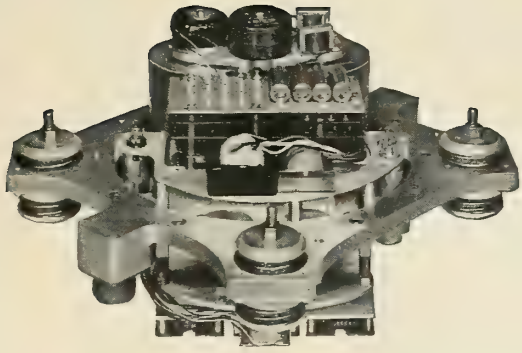
Last month's speed for Aerojet torpedo should have read 155 knots instead of 140 . . . More on underwater: Power of single nuclear plant for submarines tops 30,000 horsepower . . . Will USAW system require volunteer frogmen to listen for lurking subs the way DEW requires Ground Observer Corps? . . . Japs are building a 30,000 ton underwater oil tanker.

And an expert on the subject suggests the difference between engineers and others who write is that engineers say "a coffee containing cup" when they mean a cup containing coffee . . . Aviation pioneer Glenn L. Martin could have meant missiles when he said: "Structures and machines are unforgiving of the cheater and inevitably indict those who toy with the facts."

Some signs of our times include the fact that you can now buy surplus Lark liquid rocket engines in Los Angeles . . . Space Flight Inc. has been formed in Washington, D. C. . . . Dr. Stuhlinger has an ion-propelled space ship design with a 150-ton payload and a 23,000 kw power plant . . . If General Schriever had had his way, Western Development Division would now be called Space Weapons instead of Ballistic Missile Division . . . Distribution of booklet "Toward Outer Space," prepared for employee take-home racks, now exceeds 500,000 . . . Something, this page hears, that "can hit a football 100 miles up" may soon be fired from Patrick—an anti-missile missile, maybe? . . . National Science Foundation is building 150-foot diameter celestial listening antenna in West Virginia. . . . A nuclear physicist probing space propulsion problems claims science-fiction writers are all wrong—"They're too conservative" . . . With the trend towards high-energy propellants, it may be significant that chemical industry can supply 100 tons of fluorine per day, if the market demands.

As though missile testers weren't having enough trouble fighting fires from fizzled missiles, radio-gremlins now rear their unpredictable heads. Note: The Bomarc whose engines were cut off a few feet from launching by a stray radio signal from the pad next door; the lady taxicab dispatcher in Los Angeles who unwittingly brought ulcers to Firebee developers by repeatedly popping drone's parachute ahead of time. Postal regulations prohibit publication of Patrick AFB views on radio hams in South America, who are beyond the range of FCC control . . . And for a new twist in travel, note to the right, a pattern for escape. . . .





Here is the first photograph of the guidance reference system for Project Vanguard. Designed and built by Honeywell Aero, this sensitive electronic mechanism must keep the finless rockets on course despite intense vibrations and tortuous accelerations hitherto unknown. Because of these rigid demands, rugged, precise HIG-6 gyros were selected to sense pitch, roll and yaw in the system. The Vanguard Reference System is another example of Honeywell Aero's leadership in air-borne control systems.

AERONAUTICAL DIVISION, MINNEAPOLIS-HONEYWELL

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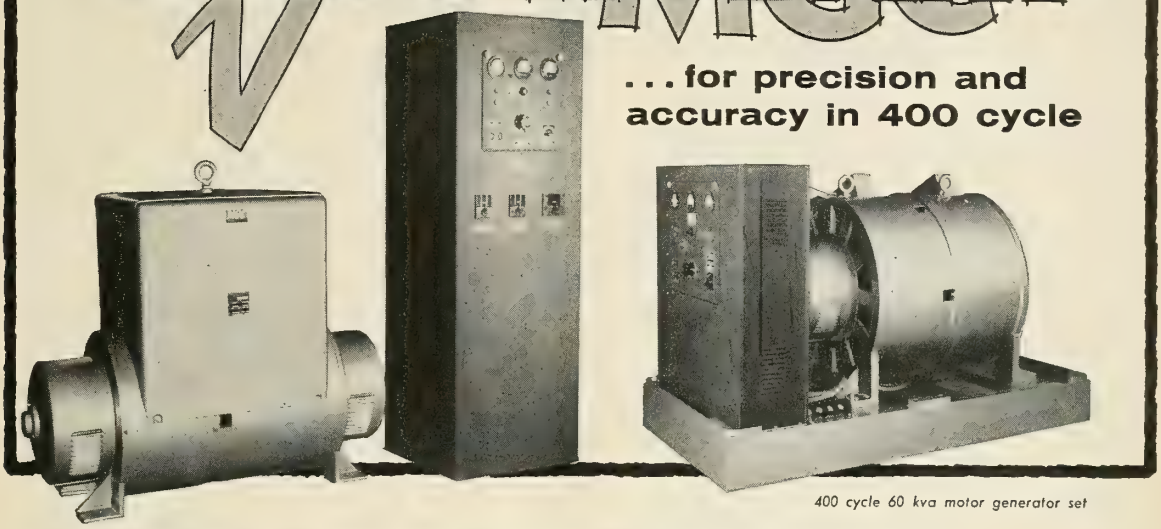
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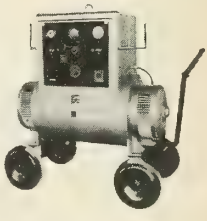


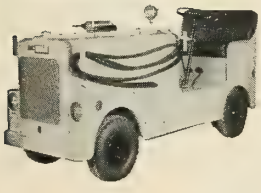
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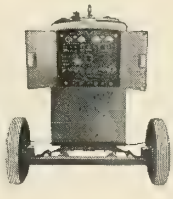
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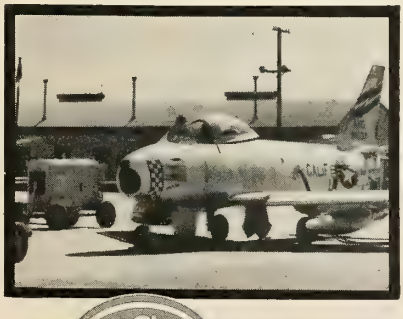
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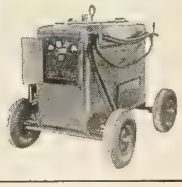
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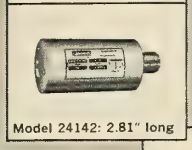
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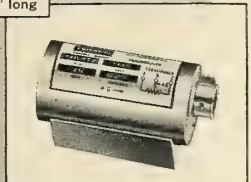
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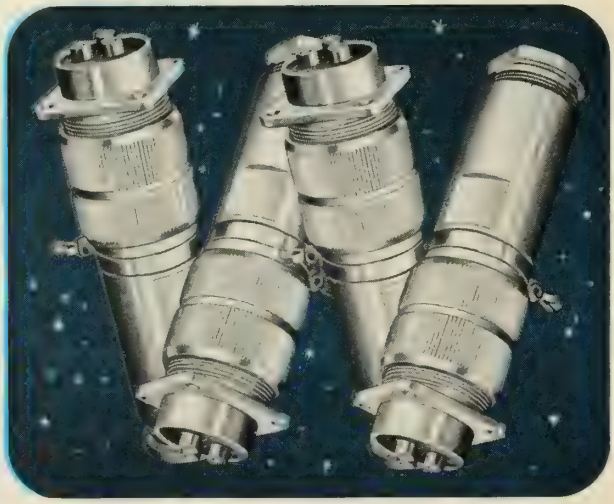
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International Scene

By Anthony Vandyk

The Bristol Aeroplane Company's investment in guided weapon development has now reached the point where it is the largest single activity except for the Britannia turboprop transport. This was revealed when the Bristol organization announced that its *Bloodhound* SAM is now in production. The ramjet powerplant of this supersonic missile is manufactured by Bristol Aero-Engines while the radar and servo control guidance equipment is supplied by Ferranti. Overall responsibility for the *Bloodhound* has been entrusted to Bristol Aircraft. Both Bristol Areo-Engines and Bristol Aircraft are subsidiaries of the Bristol Aeroplane Co. The *Bloodhound* is described by its manufacturer as a complete missile defense system including ground warning radar stations, control stations and the missile itself. As such it should be attractive to the many foreign nations in need of "packages" of this type.

•

The first launching of the de Havilland *Firestreak* infrared-seeking AAM from an aircraft took place in a most undramatic way. The aircraft, a Venom all-weather fighter, was stationary on the Pendine Sands near the Aberporth range in Wales. The nose of the aircraft was pointed out to sea and jacked up, and an anti-blast door was fitted over the landing gear. The chief test pilot of the de Havilland Propellers and the *Firestreak's* system's engineer, D. de Villiers and C de B. White, respectively, entered the cockpit and adjusted their safety straps. White pressed the firing button and the missile left the aircraft successfully.

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The following data on French missiles have been published by the French Aircraft Industries Association. The association points out that the list is necessarily incomplete and contains only information on relatively old missiles which have been totally or partially declassified.

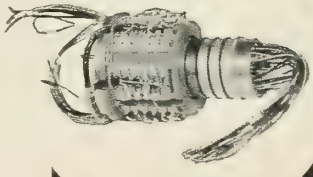
Manufacturer	Model	Range or Ceiling	Propellant	Max. Speed
SSM				
*Nord	S.S. 10	5,200 feet	Solid	190 mph
*Nord	S.S. 11	11,500 feet	Solid	430 mph
*DEFA	Entac	5,200 feet	Solid	190 mph
*Sud-Aviation	S.A. 4200	75 miles	Solid-Ramjet	High subsonic
SAM				
**Sud-Aviation	4.100	39,400 feet	Bi-fuel rocket	Mach 0.8
***Sud-Aviation	4.300	.....	Bi-fuel rocket	Secret
*DEFA	Parca	82,000 feet	Liquid	Mach 1.7
	Maruca	.....	.....	.....
	Masalca	.....	.....	.....
AAM				
*MATRA	M.20	5,200 feet	Liquid	Mach 1.5
**MATRA	M.04	.....	Liquid	Mach 1.5
*MATRA	M.051	.....	Solid	Mach 1.5
*NORD	5103	13,100 feet	Solid	Mach 1
DRONE				
*Nord	5501-C.T.10	30 miles	Pulsejet	280 mph
	5501-C.T.20	120 miles	Turbojet	560 mph
SONDES				
**DEFA	Veronica	160 miles	Liquid	Mach 2
*ATEF	Monica	65 miles	Liquid	Mach 4

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World Astronautics

By Frederick C. Durant III

The American Rocket Society has completed a full circle on aims and interests. Originally founded in 1930 under the name American Interplanetary Society, the ARS published a journal, "Astronautics," from 1932 to 1944. The avowed purpose of the society was to encourage the development of manned space flight. Rocket engines were designed and operated by this small group of earnest amateurs.

By 1945, however, the problems of space flight appeared greater and greater. Some of the industrial barons of the rocket industry didn't like the "crackpot" influence. The society renamed itself—its present title—and hedged further by renaming its journal "The Journal of The American Rocket Society," later, "Jet Propulsion." Now, it is announced that this July the ARS will publish "Astronautics" as a sister magazine to JP.

The full story of the trials and tribulations of the directors and officers of the ARS during the past decade have never been disclosed. Certainly there has been a lot of heat behind scenes between right and left wingers. When the current president of the ARS was a director some years ago, he stopped attending board meetings because he was unable to elicit any enthusiasm over astronautics. But times change. Astronautics is no longer a dirty word and those who have had faith through the years, such as Ed Pendray, Bob Truax and Andy Haley may understandably be excused a grin of self-gratification.

In retrospect it might be argued that the conservative approach was actually the better. The society was accepted more readily by the professionals and the policy battles provided a natural yeast for the rapidly growing organization. Let's hope the yeast doesn't disappear.

•

At first thought one would believe that if a satellite is accelerated in its orbit by additional thrust, it would move to an orbit of greater altitude and have a higher velocity. The larger orbit would be expected from the balance between centripetal force and the force of gravity. Actually, in moving to a higher altitude the satellite velocity is reduced. Energy is absorbed by the satellite mass and retained as potential energy. Satellite velocity at 300 miles altitude is about 18,000 mph. At 8,000 miles altitude, satellite velocity is only 10,000 mph. Escape-velocity from the greater orbit is about one-half that of the lower.

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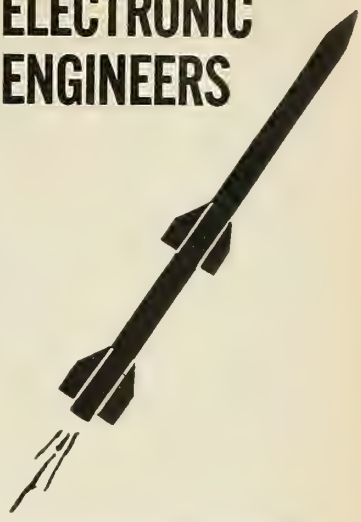
A. G. Haley, Washington lawyer and astronautical legal expert, recently witnessed a firing, under Eugen Saenger's supervision, of a hot water booster rocket in Stuttgart's Forschungsinstitut fuer den Physik der Strahlantriebe. One static run of this unit costs only about 25 cents. On noting Haley's surprise at this low figure, a German was overhead to comment, "That's the first time I ever saw an American amazed by a *small* number!"

•

At the Space Flight symposium held at the Cambridge meeting of the American Astronomical Society recently this question was asked of SAO Director Dr. Fred L. Whipple: "What are the odds of at least one of the U.S. satellites being placed in orbit?" The reply: "Ninety-nine per cent." When questioned as to the value of space flight to the man-in-the-street, Dr. Whipple gave serious consideration and replied, "About the same as the cyclotron was in atomic research 20 years ago." It is always hard to justify basic research, particularly in terms of dollar value. How much was $e=mc^2$, the postulated relationship, worth 20 years ago?

Another speaker, Dr. Gerard deVaucouleurs, who is a recognized authority on Mars related ". . . After many hours observing Mars, I came to the conclusion. . . . that is, it is a long way off and you cannot see much!"

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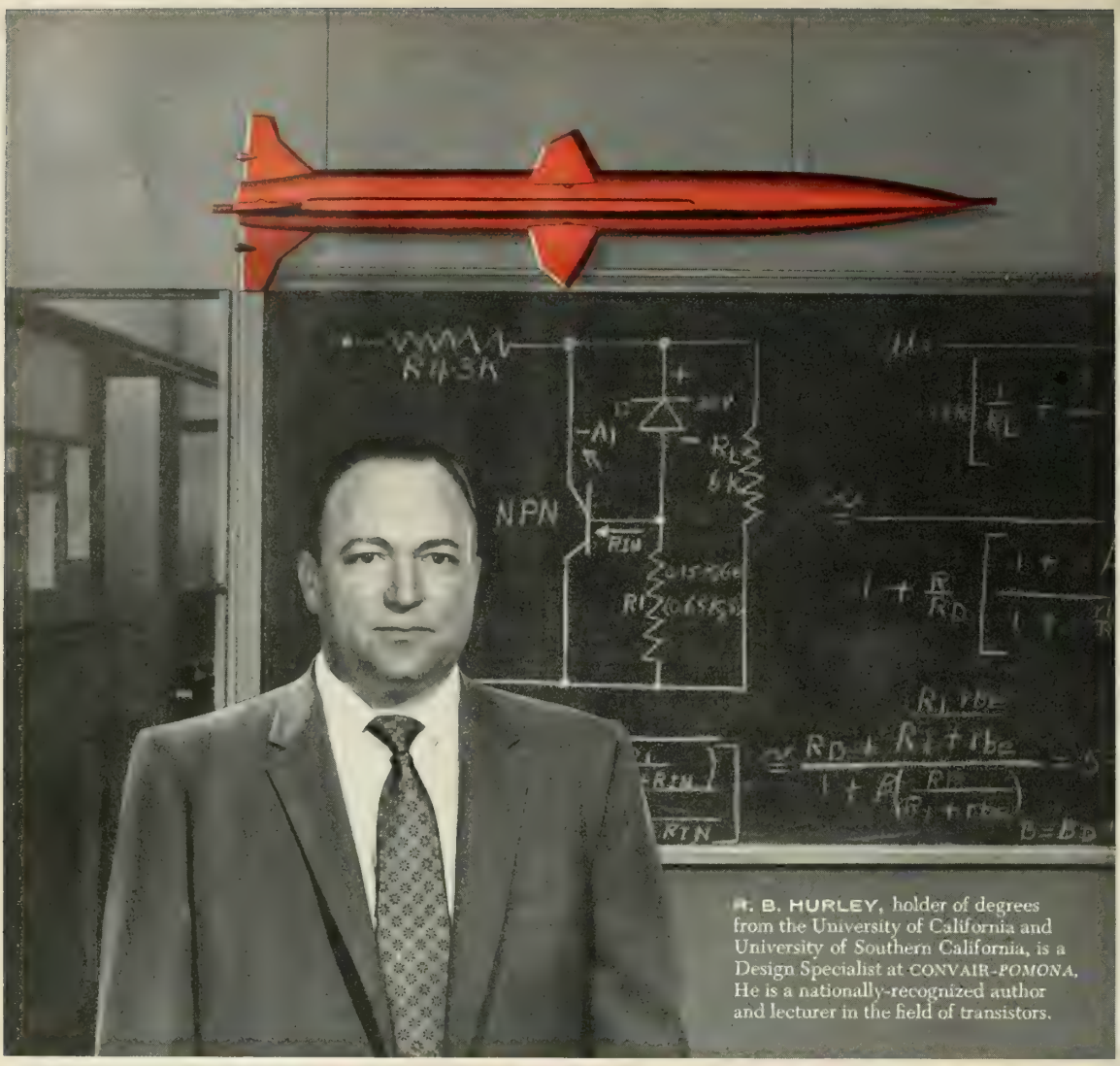
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R. B. HURLEY, holder of degrees from the University of California and University of Southern California, is a Design Specialist at CONVAIR-*POMONA*. He is a nationally-recognized author and lecturer in the field of transistors.

"Engineers—here's how we're taking part in the electronics revolution toward solid state devices"

"Here at CONVAIR-*POMONA*, we are constantly studying ways to apply the new miniature solid state electronic devices: the diode, rectifier and transistor. So new is this semiconductor infant, and so vast its future—both for the military and industry—that our teams of electronics engineers actually 'go to school' under some of the foremost experts in the field.

"As the *first* fully-integrated missile plant in the U.S., CONVAIR-*POMONA* designs and builds the Navy's TERRIER supersonic missile. And, realizing the potential value of solid state devices in meeting the critical requirements of such airborne missiles, we initiated a 'transistor program' early in 1953. This program has multiplied many times to become one of the most important in the industry.

"You, as an engineer, can appreciate the tremendous expansion that will come in the application of solid state electronic devices in the next few years. And you can readily understand the advantages of studying and working with these devices, guided by the advanced thinking you will find at CONVAIR-*POMONA*.

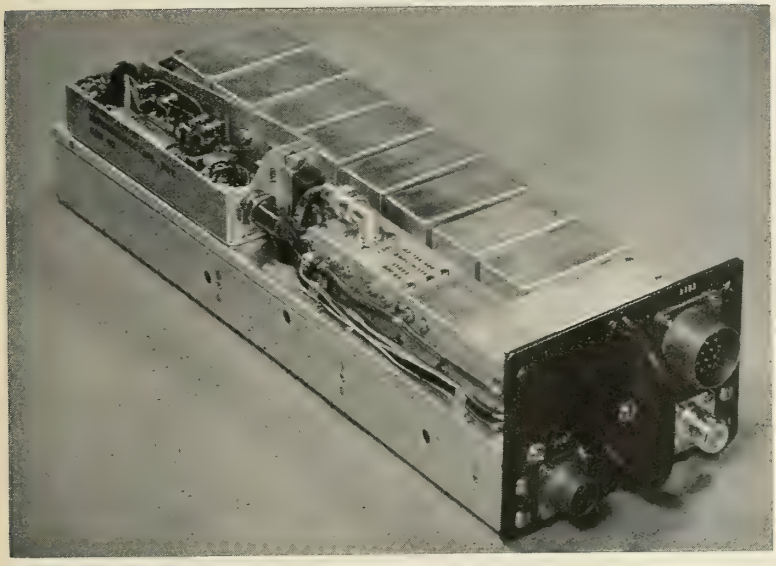
"You'll like the atmosphere here, where you see and feel accomplishment. And you will enjoy living in Southern California's beautiful Pomona valley. For greater career opportunity—*for your future's sake*—send for more information about CONVAIR-*POMONA today!* Write to: Engineering Personnel, Dept. M-3

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NEW MISSILE PRODUCTS

GUIDED MISSILE RECEIVER



Modular packaging techniques have been applied to a 400 mc radio receiver designed by Bell Aircraft Corp. for conditions where vibration presents a problem. For use where demodulated signals for the activation of a communications system are needed, the receiver is said to provide a high signal-to-noise ratio, high sensitivity and stability, and wide bandwidth.

Bandwidth within the tuning range is 402-420 mc and plug-in assemblies are available to extend this to 500 mc. Easy servicing is accomplished by modular plug-in units. Power input required is less than 50 watts and the receiver may be operated in a 15g environment from 5 to 2000 cycles at temperatures from —55° to +72°C.

Circle No. 212 on Subscriber Service Card.

AC ACCELEROMETER



A new accelerometer by Genisco, Inc. uses inductive output in conjunction with the sensing element of the Genisco Model DDL accelerometer. Standard range is 0.1 g to 10 g.

Voltage input is 28 volts or on an optional basis is 115 volts at 400 cycles or 5000 cycles. Output voltage is 10 volts maximum for 28 volt input for ranges of 1 g or higher.

Circle No. 219 on Subscriber Service Card.

WIDE RANGE ACCELEROMETERS

Columbia Research Laboratories offers wide range Accelerometers, Series, 400, employing barium titanate in compression and having natural frequency of 75kc. These instruments operate over a broad acceleration range from 0.03g to 40,000g and over a frequency range from 0.05 cps to 20,000 cps, with a sensitivity of 30 mv/g±5% throughout usable range. Pickups are available in various sizes, weights and mounting configurations.

Circle No. 218 on Subscriber Service Card.

MISSILE MOTOR

New dc motor developed by Electrical Engineering and Manufacturing Corp. for missile and rocket applications weighs 7.25 lbs. and conforms to Spec. MIL-8609.

EEMCO Type D-927 motor is rated at 0.5 hp at 9,900 rpm continuous, terminal voltage 27 v, 18 amps. An optional two-circuit noise filter for ungrounded systems adds one pound to motor's weight.

Circle No. 203 on Reader Service Card.

ELECTROLYTIC LEVEL SWITCHES

New electrolytic switches produced by Corning Glass Works are arc-shaped gravity sensor devices made for both off-on and proportional control of missile directional systems.

Level and deviation from level are indicated within tenths of a degree by means of the switches. The switches are filled with an electrolyte which is said to give them six times less mass shift than mercury counterparts. Temperatures of up to 200°C can be withstood. Units are supplied in regular and subminiature sizes.

Circle No. 224 on Subscriber Service Card.

SILICON RECTIFIERS

Four new silicon rectifiers are being produced by the General Electric Co. Designated 1N1115, 1N1116, 1N1117 and 1N1118 the new units are stud mounted. Voltage ratings for peak inverse conditions are 100, 200, 300, and 400 volts with a maximum rms of 70, 140, 210 and 280 volts respectively.

They are designed for a maximum output of 600 ma at a case temperature of 150°C.

Maximum operating frequency for the units is 100 kc. They have a 10-32 stud for chassis mounting and are housed in a welded, all-metal case.

Circle No. 226 on Subscriber Service Card.

MINIATURIZED GYRO

Model 55,000 floated rate gyro has been designed by Norden-Ketay Corp. for missiles. A variety of maximum rate ranges from 1°/sec. to 1000°/sec. can be supplied. Accuracy better than ½% is



claimed while the gyro is subjected to severe missile environments.

Damping ratio is obtained without a heater by an arrangement that provides for verying the gap between the gyro rotor float chamber and an adjacent member. Damping ratio can be established to suit requirements of customers and maintained within 0.1 over a temperature range of —55°C to 85°C.

Circle No. 208 on Subscriber Service Card.

RADAR BEACONS

Avion division, ACF Industries, Inc. is producing four radar beacons for missile and aircraft use in "C", "S" and "K" bands. The pulse-type tracking aids respond to coded and uncoded pulse interrogations from radars. The "C" band unit delivers 100 watts and weighs 61 oz. The "S" band units deliver 2 and 1000 watts and weigh 51 oz. and 25 lbs. The "X"

band unit delivers 50 watts and weighs 59 oz.

The low power units operate from a self-contained transistorized power supply operating from batteries, and the large "S" band unit requires 28 volt dc.

Circle No. 210 on Subscriber Service Card.

ENVIRONMENTAL TESTER

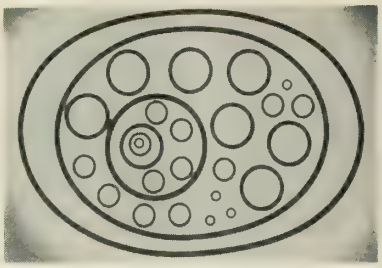
New environmental chamber for testing rocket and missile components, principally for electronic testing and stabilization of metals, has a range of —125°F to 350°F Produced by Webber Corp.

The Model WE-3-125 has a pull-down time from ambient to —100°F of about 45 minutes, to —125° in about one hour, and will raise temperature from —125° to 300°F in about 15 minutes.

Unit capacity is three cubic feet and internal dimensions are 16 x 16 x 16 in. Overall measurements are 28 in length, 32 in. width and 66 in. height.

Circle No. 201 on Reader Service Card.

"O" RINGS



A new line of red silicone rubber "O" rings designated Style 9599 has been announced by the Garlock Packing Co. of Palmyra, N. Y. The new rings are manufactured from 70 durometer hardness stock exhibiting low shrinkage and compression set.

The "O" rings, available in standard AN sized, are recommended for dry heat service on which synthetic rubber compounds and natural rubber do not maintain their rubber characteristiccs. The silicone rings resist oxidation, withstanding indefinitely continuous exposure to hot air and temperatures up to 300°F, and in most applications will withstand for long periods of time, exposure to dry heat at temperatures from 300°F to 500°F.

Circle No. 211 on Subscriber Service Card.

SILICON TRANSISTORS

Texas Instruments, Inc. has announced the recent addition of fifteen new silicon transistors to its line of high temperature devices and brings to 36 the number of such units currently manufactured by the company.

All of the new units are in round cases and are designed for production by automatic techniques in addition to meeting military requirements.

Three years ago the company introduced silicon transistors which are ideal for military use because they operate stably at temperatures up to 150°C.

The new line includes two switching transistors, tetrodes, medium power types and five small signal units.

Circle No. 204 on Subscriber Service Card.

THROTTLING VALVES

Greer Hydraulics, Inc., has developed a series of precision throttling valves which are adaptable to a variety of installations. The series is designed for use with oils, fuels and other liquids compatible with aluminum and steel in central hydraulic systems, missiles systems, and test equipment. They also can be provided in other materials for use with water, acids and other corrosive liquids.



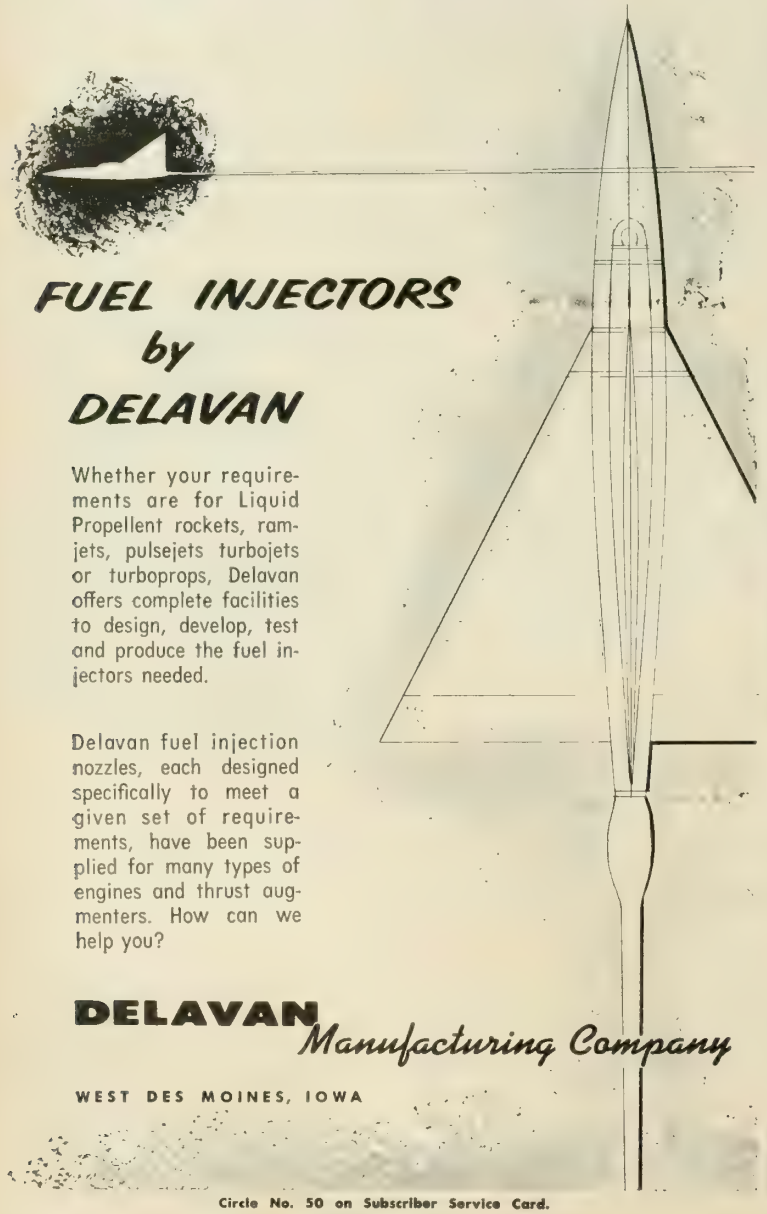
Featuring low torque, the valves are available with 2", 1½" and 1¼" ported flanges adaptable to one basic body size; and 1", ¾", ½" ⅜" and ¼" ported flanges adaptable to another basic body size. Valve body can be removed without breaking the line, and valve seat replacement can be made without removing body from line.

Circle No. 215 on Subscriber Service Card.

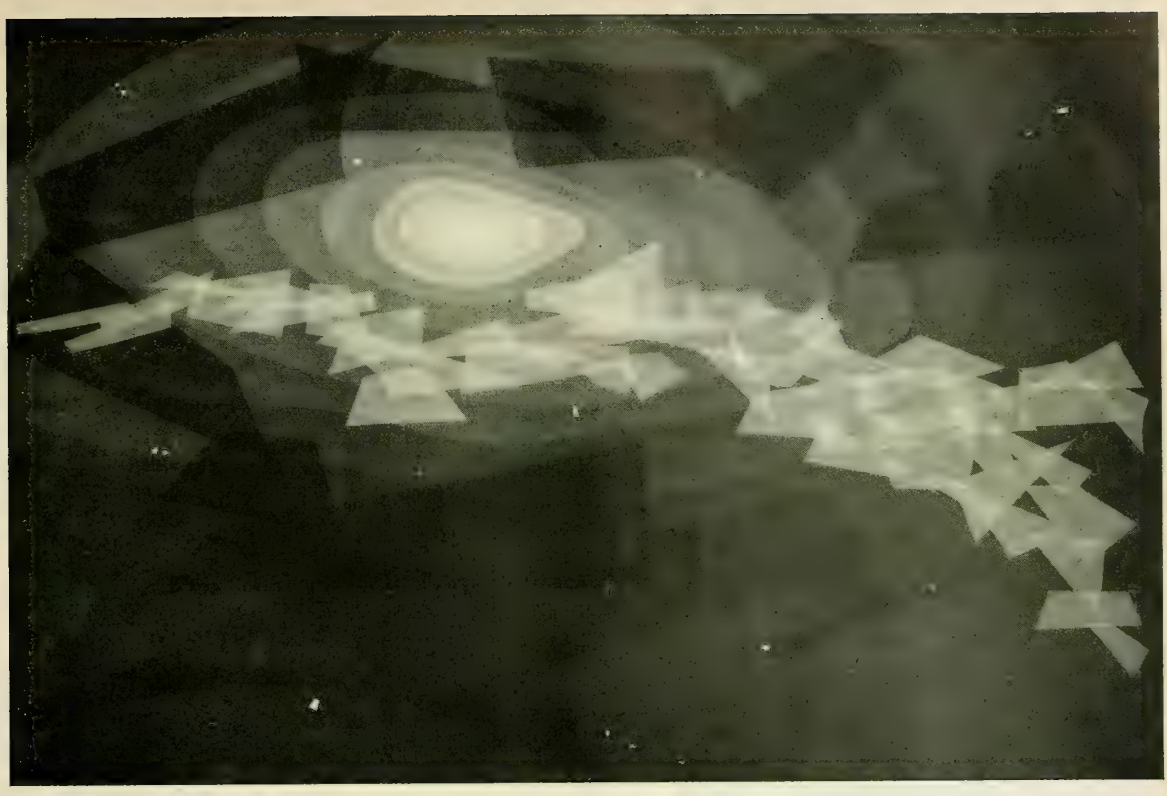
ACCELEROMETER

Genisco, Inc., has made design changes in its Model GMO Accelerometer which make it particularly adaptable for use in guided missile flight control systems. The 8-oz., viscous-damped potentiometer-output instrument is available in ranges from ±2G's to ±30G's, hermetically sealed.

Specifications: Undamped natural frequency 15 to 40 cps; linearity within 1% of full scale from best straight line; damping 0.3 to 2.0 of critical; output resolution proportional to number of turns of



Circle No. 50 on Subscriber Service Card.



"CYGNUS", another inspiration by Simpson-Middleman, painters of the meanings of science. "Knowledge of the Universe," say these artist-scientists, "is not a matter of man's sight, but of his imagination's vision. Our eyes show us Cygnus. But creations of our genius, such as the radio-telescope, reveal unexplored, unexplained sources of energy that man may someday master. They lie amidst and even beyond those mysterious, drifting clouds of cosmic matter, lit by the stars they do not obscure." Painting courtesy John Heller Gallery Inc.

You'll find an *interesting* future at Boeing

Boeing engineers and scientists are concerned with all phases of flight, including the problems of outer space. If you like to work in advanced areas of exploration, you'll be right at home at Boeing. Here engineers and scientists are busy on such projects of unusual interest as determining the performance of solar cells in flight environments encountered at altitudes up to 200,000 feet.

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You can begin an *interesting* long-range career by dropping a note now to: *John C. Sanders, Engineering Personnel Administrator, Boeing Airplane Company, Department R-64, Seattle 24, Washington.*

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● Tested and proved in the aircraft industry, Convoluted Teflon Actionflex Tubing is now available for expansion joints and other industrial applications requiring the temperature and corrosion-resistant qualities of Teflon. Write for Engineering Bulletin.

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By the makers of *Actionrod* fishing tackle

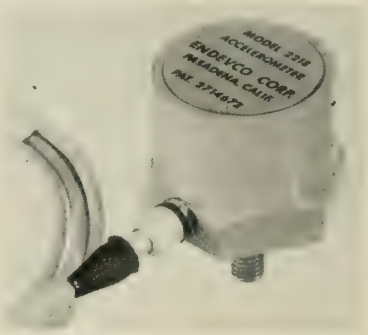
Circle No. 51 on Subscriber Service Card.

wire on the potentiometer, generally 0.34% of full scale; hysteresis generally less than 0.5% of full-scale output; potentiometer resistance 2 to 15K; power rating 2 watts; axis alignment within 1.0°; operational life 2 million complete cycles.

Circle No. 225 on Subscriber Service Card.

LOW G ACCELEROMETER

An accelerometer that measures values of g down to 0.03 has a minimum sensitivity of 40 millivolts per g. The Model 2218 unit has a natural frequency of 20 kc minimum and gives a response from 2 to 4000 cps with a linearity of 5 percent.

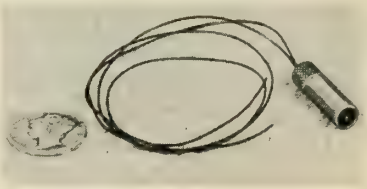


Response to high level noise is virtually eliminated by clamped crystal design and internal acoustic shielding. Temperature characteristic of the new unit made by Endevco Corp. is linear within 10 percent from —65° to 230°F. It weighs 2 ounces and is 1 inch hexigon in size.

Circle No. 221 on Subscriber Service Card.

SUB-MINIATURE TRANSDUCER

Electro Product Labs, Inc. has introduced a sub-miniature magnetic pickup that generates electrical signals from mechanical motion with physical contact. The unit weighs about 4 grams and is about ¼" in diameter.



The tranducer senses movement of ferrous objects and produces a signal proportional to the rate of movement. An Alnico magnet is used to energize the device.

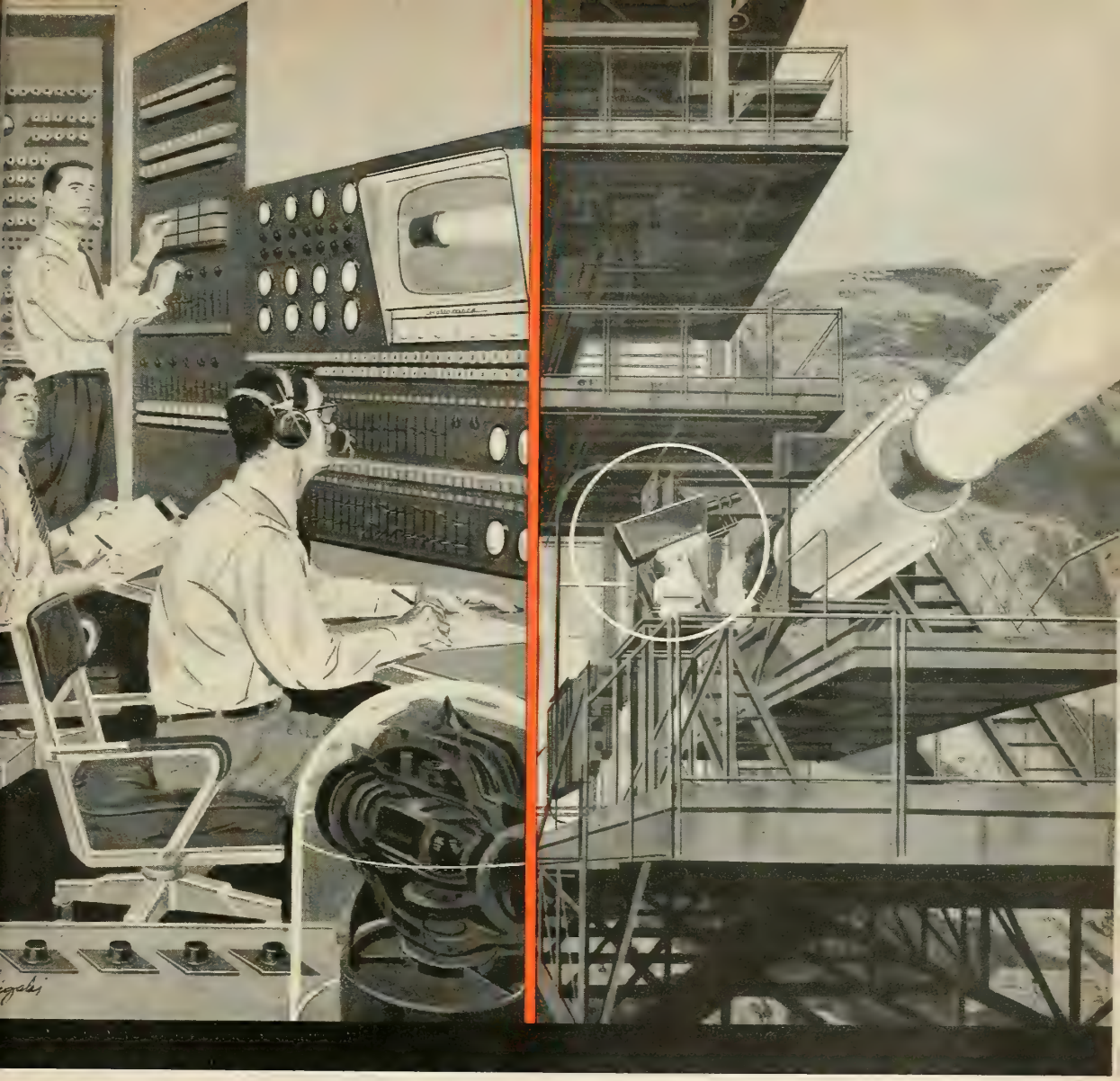
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VERTICAL GYRO

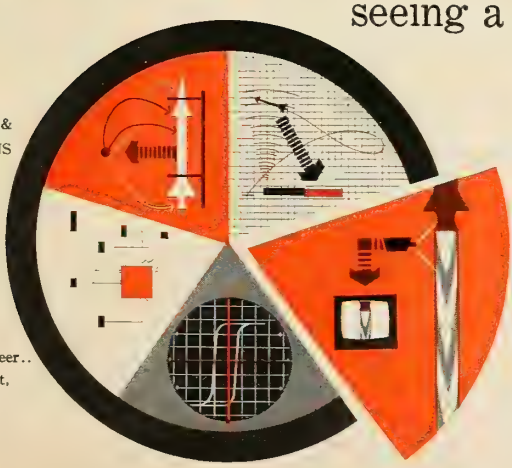
Waltham Watch Co is producing a vertical gryo Type WG-2 which provides accurate and reliable two-axis vertical reference data in the form of two synchro output signals.

The spin-axis is slaved to gravity by a gravity sensitive vertical reference device which supplies electrical control signals to torque motors which maintain the gyro spin-axis parallel to the gravity vector.

Vertical repeatibility is to within 10 min. of the arc cone and the initial erec tion from any standing position at any temperature from —55° to 71°C to within



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Far too hot, and positively too ear-splitting, for close, on-the-spot observation by human beings...when high thrust propulsion units are fired up for test, Hallamore closed-circuit television takes over the job. Throughout industry, similar Hallamore systems are finding application...wherever the requirement is for remote observation or for fast transmission of visual impressions. Hallamore Electronics designs, develops and manufactures missile ground support and in-flight instrumentation systems, magnetic products, electronic components and audio visual communications systems. Current activity includes contracts for the United States armed forces and prime contractors of the aircraft and ordnance industries.

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plus 30 min. of arc of vertical within 25 sec. after application of power. Altitude capabilities are unlimited and operating life is at 1,000 hrs. minimum.

Circle No. 200 on Subscriber Service Card.

PRESSURE TRANSDUCER

A pressure transducer being manufactured by Servonic Instruments, Inc. operates under vibration environments of 20g and temperatures to 400°F. The Model "H" transducer uses stainless steel sending elements that permit use of corrosive fluids in either gauge or differential models.

Case burst pressure is rated at 7500 psi and ranges from 1000 to 10,000 psig or psid are available.

Circle No. 206 on Subscriber Service Card.

DC GENERATOR

John Oster Manufacturing Co. has developed a permanent magnet dc generator which is said to have an unprecedented high output for its size and weight.

Type 13-PG-6901-01 has a 10-watt output at 10 vdc at 8,000 rpm continuous duty with 1,000-hr. life and 25°C maximum temperature rise. Diameter is 1.25", length 2.6", weight 7 oz., has 3 oz.in. input torque, face mounted. Designed for any dc generator application requiring exceptionally high dc output.

Circle No. 202 on Subscriber Service Card.

PERMANENT MAGNET MOTOR

John Oster Manufacturing Co. has unveiled a 1¼ in. permanent magnet gear reduction drive motor it believes is



the first of its type and size to be provided with a brake.

The Oster unit combines motor, brake and gear train into a single unit. Design features include a reduction to 2.5° maximum of the coast of the output shaft from no load speed to 30 volts dc. No load output is five to 10 rpm at 24 to 30 volts dc and minimum stall torque is 30 oz.

Overall length of unit is 3.89 in. plus shaft and operating temperature range extends from —65° to 160°F.

Circle No. 232 on Subscriber Service Card.

COMPUTER INDICATOR TUBE

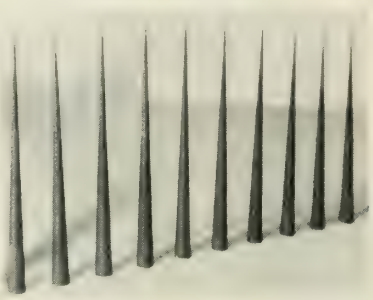
Amperex Electronic Corp. has announced a new Type 6977 filamentary subminiature indicator triode with fluorescent anode for visual monitoring of transistorized computers and other transistor circuits.

Heater voltage required is 1 volt at 30 ma ac or dc. The anode draws 0.6 ma from a 50 volt supply during 0-bias "on" conditions. A 3.5 volt signal is sufficient to cut off plate current and the light.

Circle No. 207 on Subscriber Service Card.

RF ABSORBER

Emerson and Cuming, Inc., makes a series of plastic rod and sheet forms of Eccosorb MF plastic for waveguide and coaxial lines as absorbers, attentuators, terminations and loads over the entire microwave frequency bands.



The material is nonporous and needs no moisture protection on machined surfaces. It can be used up to 350°F. Suggested designs for both step and uniform tapers are available.

Circle No. 209 on Subscriber Service Card.

MISSILE SOLENOID

A miniature pull-type solenoid for missile applications which operates with efficiency and low plunger friction loss, has been developed by Carruthers & Fernandez, Inc.

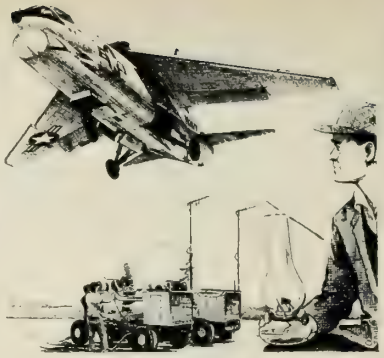
Operating range —65° to 100°F. Solenoid provides positive, trouble-free operation on computing devices in missile components at high altitudes and speeds. Operating voltage from 6 to 100 vdc with plunger operating under side force of 8 to 10 g. At .3 amps, 100 vdc and 78°F, force is 1.3 lbs. with stroke .03". At same conditions force is .8 lbs. with stroke .06"; and .4 lbs. with stroke .125".

Circle No. 217 on Subscriber Service Card.

GAS COMPRESSOR

An oil free gas booster compressor, designed by Haskel Engineering & Supply Co., serves as a source of high-pressure, dry, uncontaminated helium or nitrogen for missile and test applications where gas cleanliness is of utmost importance.

The compressor uses a variable inlet pressure source and is operated without lubrication. It delivers outlet gas pressures from 6,000 to 10,000 psi with average capacities from 10 to 20 scfm using inlet pressure sources between 500 and 2,200 psi. Compression is accomplished



FOUR OPENINGS FOR FLIGHT TEST INSTRUMENTATION ENGINEERS

Electronic Development Instrumentation Engineer. To conceive, design, laboratory-evaluate and test intricate components and assemblies aimed at automation of data acquisition and analysis. Requires Electronics or Physics degree and one to four years experience in electronics design.

Instrumentation System Design Engineer. To develop and coordinate over-all instrumentation system designs and measurement techniques for collecting data for any engineering field. Requires Engineering degree and one to four years related instrumentation experience.

Field Operations Instrumentation Engineer. To operate and add to an automatic data gathering and analyzing station containing telemetric and magnetic tape playback equipment. Electronics or Physics degree plus one to four years electronics design or test experience.

Lead Instrumentation Project Engineer. To direct over-all instrumentation system design for major aircraft series or model. Engineering degree and six years instrumentation experience.

To arrange for a personal interview, or for a prompt report on these or other openings, return coupon to:

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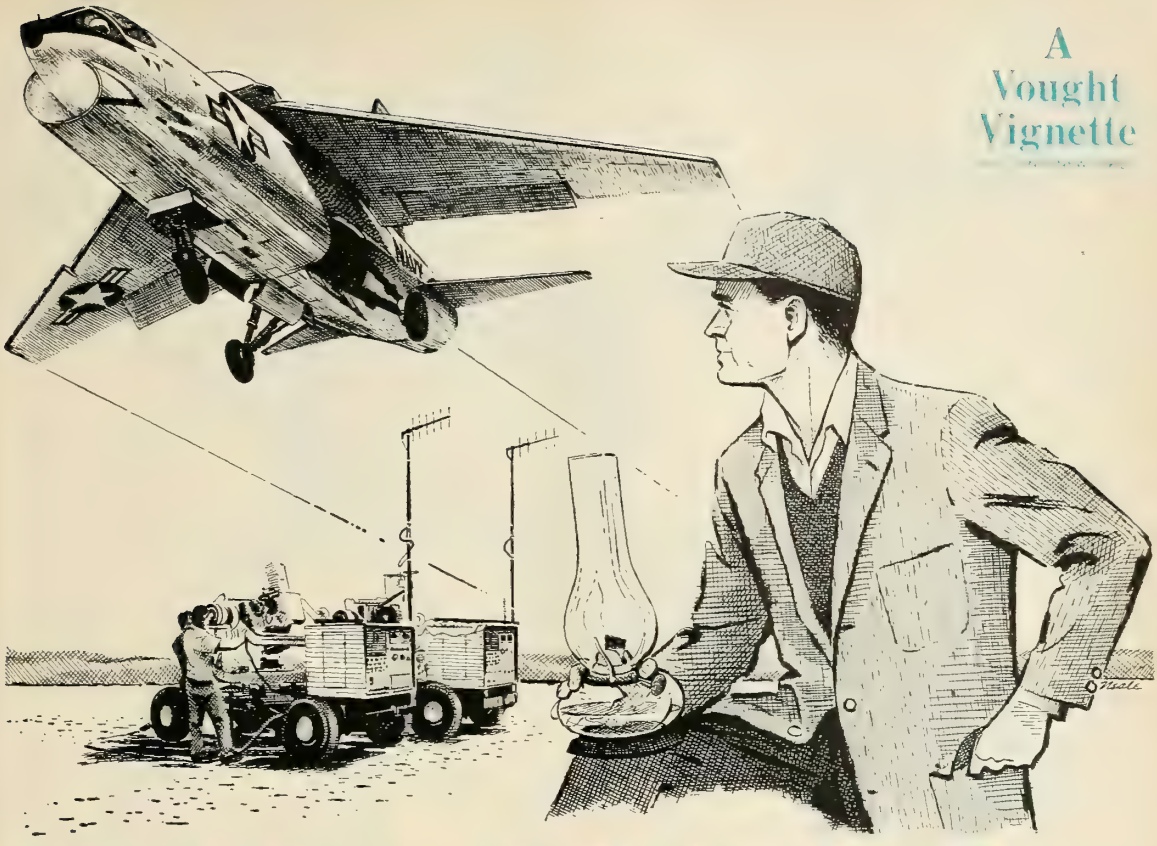
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City and State_____

MR-4



A Vought Vignette

Soot Solved This Problem

One thing Richard (Rick) MacDonnell could say for flight test instrumentation — it had variety. Here he was, in line of duty, hunting a coal oil lamp on the Mojave Desert.

Looking back, Rick saw that the whole Crusader instrumentation program had been a series of shifting scenes. He'd started by talking to different specialists, finding out the kinds of flight information they wanted. He learned a lot about heats, loads, amplitudes and flutter. These were the things Rick's instrumentation would have to detect.

Designing and building the system took him in another direction. There was the airborne equipment — up to 12 miles of wiring and 600 pounds of black boxes for a single demonstration aircraft. Each sub-system was environment-tested, breadboarded, checked out and packaged to fit key corners of the Crusader structure.

Taking shape at the same time was a mobile ground station — another project with which Rick was associated. It brought flight test telemetering and data processing closer to automation than they'd ever been before. At Vought's Mojave Desert test base, Rick's equipment clicked. It speeded preparation for the Crusader's dramatic operational debut — the Thompson Trophy-winning speed run.

There was just one hitch — a National Aeronautical Association rule which would limit altitude deviation to 328 feet during the Trophy dash. A Bureau of Standards barograph would ride with the pilot, its stylus etching out exact altitude on a smoked cylinder. Fair enough — but Vought's desert crew didn't have a workable way to blacken duplicate cylinders for practice. And precise warm-up flights were essential.

That's why Rick went hunting for a coal oil lamp. He found one in the store of a desert outfitter. Back on the base, the lamp was lighted and the wick turned up. It "sooted" the purpose perfectly.

Instrumentation means development adventure and variety at Chance Vought. Here, engineers of all specialties use initiative and self-expression to contribute to some of the most advanced instrumentation techniques in the industry.

CHANCE VOUGHT AIRCRAFT



All guided by Whittaker Gyros!

Unsurpassed for accuracy and dependability, Whittaker Gyros are able to shrug off the effects of shock, acceleration, vibration, heat or cold . . . yet continue to function as smoothly as they did in the laboratory!

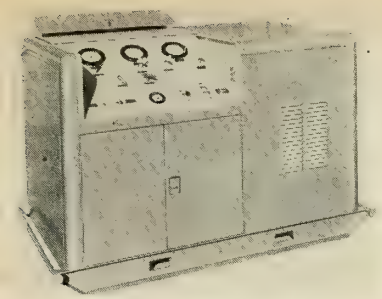
THE REASON? For all the foregoing conditions, Whittaker Gryos have been *100% tested!* Overall customer rejection — month after month, year after year — is consistently less than 2%.

And because Whittaker uses nickel alloys in frames and gimbals, steel components are permitted. The result is added strength with very little increase in weight . . . and much more overall component stability.

Whittaker Gyros are designed by engineers and built by technicians who have worked together for more than a decade. This background and experience insure exact specifications the *first* time.

Whittaker Gyro

Division of Telecomputing Corporation, Van Nuys, California • STanley 3-1950



by an integral two-stage, hydraulic driven, single-acting gas pump. Electric motor or gasoline engine prime mover is optional.

Circle No. 213 on Subscriber Service Card.

AIR COMPRESSOR

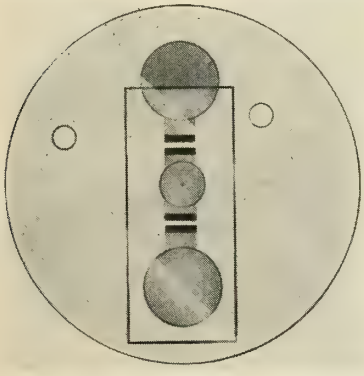
M. C. Manufacturing Co. is producing a new series of high-pressure air compressors for use in aircraft and missiles industries.

Basic compressor can be combined with 1,500 or 3,000 psi hydraulic motors, with ac or dc electric motors or mounted directly to engine pad. Compressor is of 4-stage piston type, using frictionless type bearings and has an oil capacity sufficient for 100 hrs. operation.

Rated capacity at sea level is 4 scfm, at 3,000 psi outlet pressure. Official life test is 550 hrs., weight of compressor proper 10.7 lbs.

Circle No. 214 on Subscriber Service Card.

BROADBAND DISC BOLOMETER



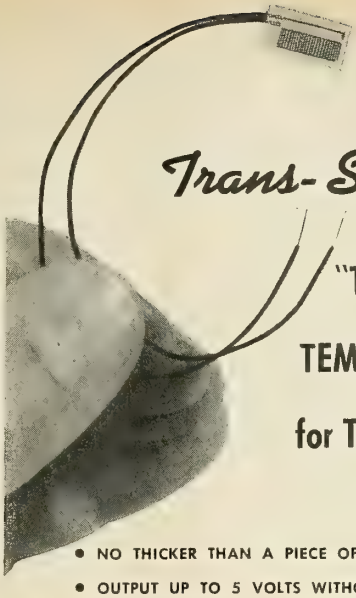
Two new broadband disc bolometers, Models N603 and N603-4.5 covering the frequency range from 500 to 10,000 mc, have been developed by the Narda Corp.

The bolometers consist of two 100-ohm Wollaston wire bolometer elements mounted on a mica disc. An rf bypass capacitor is included for the ungrounded end of the device as well as a blocking capacitor at the central junction between the elements. The bolometers are manufactured for either 4.5 or 8.75 ma bias currents.

Circle No. 205 on Subscriber Service Card.

INDICATING PYROMETER

An indicating pyrometer made by Assembly Products, Inc. is available in 21 standard ranges. The units are medium resistance and have a maximum sensitivity when connected to one thermocouple of 300°F for full scale deflection. Standard ranges begin with minus 400°



NEW

Trans-Sonics*

"TAPE-ON" SURFACE TEMPERATURE RESISTORS

for Temperature Telemetering

- NO THICKER THAN A PIECE OF TAPE
- OUTPUT UP TO 5 VOLTS WITHOUT AMPLIFICATION
- AVAILABLE IN VARIOUS RANGES FROM −300° to +400°F.
- RESISTANCE CHANGE OF 100 OHMS OVER SPECIFIED RANGE
- NO HOLES TO DRILL — QUICK AND EASY "TAPE-ON" INSTALLATION

Trans-Sonics Type 1371 "Tape-on" Surface Temperature Resistors are precision resistance thermometers with a platinum resistance winding as the sensing element. These resistors which are no thicker than a piece of tape may be applied to *any surface* whose temperatures are to be measured. In a commutation circuit, they modulate standard telemetering transmitters without amplification. The new Type 1371 "Tape-on" Surface Temperature Resistors may be added to an installation using other Trans-Sonics temperature transducers without any further circuit modification. Each resistor is furnished with 6" long fibreglas-covered constantan leads. Write for Bulletin 1371 to Trans-Sonics, Inc., Dept. 9.

*Reg. Trademark

SPECIFICATIONS

SIZE: ¼" x 5/16"

Accuracy: ±2% of full scale range

Precision: ±0.5% of full scale range

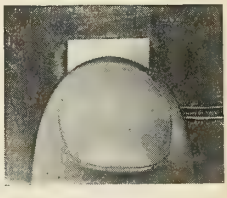
Maximum Continuous Current: 20 ma rms (averaged over 1 second)

Environmental Operation Conditions

Vibration: 1" double amplitude, 0 to 22 cps ± 25g, 22 to 2000 cps

Shock: 100g in any direction, per paragraph 4.15.1 of MIL-E-5272A (10 milliseconds shock)

INSTANT INSTALLATION



As easy to apply as a thumb print.

For Transducers, See Trans-Sonics

Trans-Sonics, Inc.

P. O. BOX 328 LEXINGTON 73, MASSACHUSETTS

Circle No. 52 on Subscriber Service Card.



Mixed Oxides are versatile, easy to handle

Propellant chemists and thermodynamic engineers seeking an oxidant uniquely suited to a wide range of rocket operating requirements find that Mixed Oxides offer these outstanding advantages:

Versatility — provides high specific impulse with many rocket fuels, including Triethyl-Trithiophosphate, Methyl Alcohol, 50% Ammonia and 50% Methyl Alcohol, 63% Triethylamine and 37% Orthotoluidine, Turpentine, Ammonia and Ethylene Oxides • **Freezing Point** — as low as —100°F, depending upon mixture • **Density** — compares favorably with other oxidants • **Easy Handling** — can be shipped, piped, stored in ordinary carbon steel • **High Stability** — non-corrosive, can be stored indefinitely in rockets maintained "at ready."

Mixed Oxides, containing 70 or 75% N_2O_4 and 25 or 30% NO, are economically available in large tonnages from Nitrogen Division's plant at Hopewell, Virginia, and for experimental purposes, in valved 125-lb. cylinders and 2000-lb. containers.

NITROGEN TETROXIDE (N_2O_4)
Oxidant for liquid rocket propellants

Molecular weight	92.02
Boiling Point	21°C
Freezing Point	—11.3°C
Latent Heat of Vaporization	99 cal/gm @ 21°C
Critical Temp.	158°C
Critical Pressure	99 atm
Specific Heat of Liquid	0.36 cal/gm —10 to 20°C
Density of Liquid	1.45 at 20°C
Density of Gas	3.3 gm/liter 21°C, at 1 atm
Vapor Pressure	2 atm at 35°C

Photo courtesy of Rocketdyne, a Division of North American Aviation, Inc.

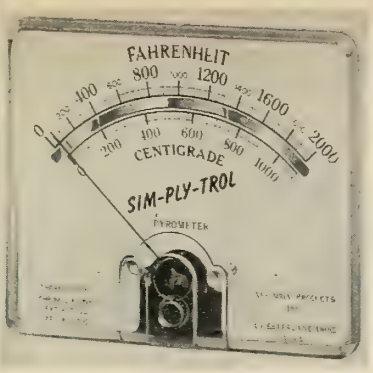
Dept. NT 2-40-1

Allied Chemical — NITROGEN DIVISION

40 Rector Street, New York 6, N. Y.

Ethanolamines • Ethylene Oxide • Ethylene Glycols • Urea • Formaldehyde • U. F. Concentrate—85 • Anhydrous Ammonia • Ammonia Liquor • Ammonium Sulfate • Sodium Nitrate • Methanol • Nitrogen Solutions • Nitrogen Tetroxide • Fertilizers & Feed Supplements

Circle No. 53 on Subscriber Service Card.



to plus 100°F and may be obtained from 0° to 3000°F.

Full scale accuracy of 2 percent is standard and 1 percent units may be obtained. The units are thermistor compensated for ambient temperature changes. Sizes are 3¾ or 4½ inches wide.

Circle No. 220 on Subscriber Service Card.

PRESSURE VESSELS

Spherical, high-strength pressure vessels for aircraft and missile applications, formed from titanium alloy or other materials, are available from Titanium Fabricators,, Inc.

Vessels range in size from 12-in. to 25-in. diameters and are formed by hot spinning hemispheres then joining with advanced welding techniques. Extensive research and development of the new welding and spinning techniques was sponsored by Convair-Astronautics.

Circle No. 248 on Subscriber Service Card.

CIRCUIT BREAKER

A circuit breaker line, designated Series AM17, which is interchangeable for 400 cycle, ac and dc use, has been developed by Heinemann Electric Co.

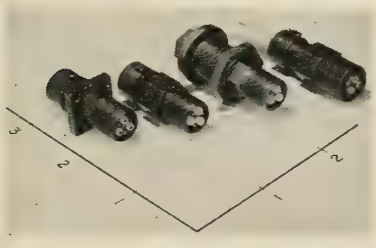
Designed primarily for aircraft circuits and airborne equipment applications, the AM17 can function either on 400-cycle ac or dc current without change in rating or essential time-delay characteristics. Series is manufactured in single-pole form only but can be readily linked to make two or three-pole companion trip units.

Breaker operates on hydraulic-magnetic principle and does not require derating for either temperature or vibration conditions.

Circle No. 235 on Subscriber Service Card.

HIGH-ALTITUDE CONNECTORS

Three series of miniature high-temperature, electrical connectors which are



reported to have superior electrical characteristics have been introduced by Consolidated Electrodynamics Corp.

Designed for high-altitude operation. the major design feature is a staggered

from DIT-MCO Inc.

. . . another startling new development in automatic electrical system testing!

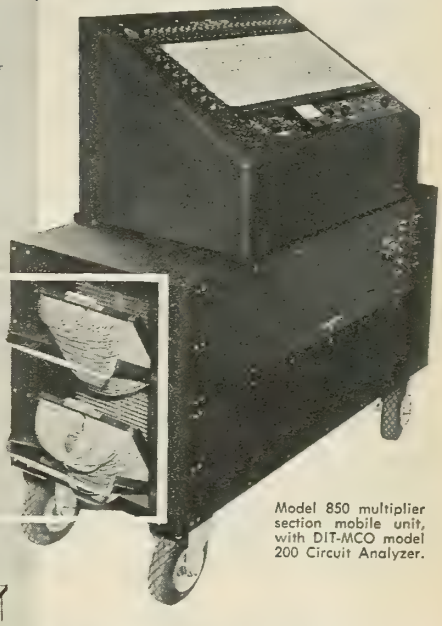
New Model 850

MULTIPLIER SECTION

featuring . . .

plugboard programming

new jumper-wire system simplifies test make-up and maintenance testing



Model 850 multiplier section mobile unit, with DIT-MCO model 200 Circuit Analyzer.



Now! In one operation at his desk, planner can design circuitry, layout matrix chart and jumper plugboard to conform to test sequence.



Now! Thorough, periodic maintenance tests can be made quickly and economically throughout the life of any airplane or missile.

Now! Test Modified Wiring Systems Without Altering Adapter Cables!

Do modified and improved electrical systems throw your testing section into a tailspin? Normally, it means existing test machinery (or the adapter cables, if DIT-MCO equipment is used) must be changed to conform to the circuit modifications. Here's how the new DIT-MCO plugboard system has solved that problem.

Circuitry can now be connected to the tester by the most convenient point-to-point method. Connecting wires (adapter cables) do not have to conform to any pattern. The testing sequence is programmed, quickly and easily, on the portable plugboards. Any subsequent circuit modifications are also handled on the plugboards . . . without changing existing adapter cables.

This is just one advantage offered by this new development. Write for full details on how DIT-MCO can help solve all your test problems.

Write today for complete information:

ENGINEERS:

DIT-MCO needs executive calibre sales and design engineers *right now!* Excellent opportunity with respected organization *on the move.* Work with key men in aircraft and missile industries. Write today!

DIT-MCO, INC.
Electronics Division

Box 06-28, 911 Broadway
Kansas City, Missouri

Partial List of DIT-MCO Users:

Bell Aircraft Corporation, Texas Div. • Bendix Aviation Corporation, Sidney, New York • Boeing Airplane Company, Seattle, Washington and Wichita, Kansas • American Bosch Arma Corporation • Douglas Aircraft Company, Tulsa, Oklahoma • Fairchild Aircraft Division • Goodyear Aircraft Corporation • Martin, Baltimore • Naval Ordnance Laboratory, White Oaks, Maryland • Northrop Aircraft, Inc. • Motorola, Inc. • Temco Aircraft Corporation • Trans World Airlines • Convair • Chance Vought Aircraft • Servomechanisms, Inc. • Radio Corporation of America • Pacific Mercury Television Mfg. Corp.

Circle No. 54 on Subscriber Service Card.



CENTURY MODEL 409D RECORDING OSCILLOGRAPH

Numerous agencies engaged in the manufacture and evaluation of missiles have turned to the Century Model 409D Recording Oscillograph as a reliable means of collecting missile performance and control data.

On-board mounting eliminates the necessity for the costly and often not reliable RF link.

The ruggedness and reliability of this 12-channel oscillograph have been demonstrated many times. One agency reports having recovered 42 satisfactory record rolls out of 43 firings. Another, using special mounting configuration, reports recording at 60 G's without damage.

This 13 lb. instrument is compact enough to be installed in most missiles and all electrical connections including remote control are accomplished through a single multi-pin AN connector.

Wire, Write or Phone

CENTURY ELECTRONICS & INSTRUMENTS, INC.
1333 North Utica, Tulsa, Oklahoma

Circle No. 55 on Subscriber Service Card.

construction which gives long creepage path between pins despite small connector dimensions. Body is of anodized aluminum for corrosion resistance. Each pin of the mated connector is surrounded by Teflon.

Design provides three separate seals—around entering wires, around each pin connection, and at the interlocking faces. This insures insulation resistance at 10^6 megohms.

Circle No. 228 on Subscriber Service Card.

RATIO TESTER

Allegheny Instrument Co., Inc., has introduced Model 11 ratio tester which can be used to measure dc voltage ratios in the range of 0 to 100% in aircraft and missile telemetering and measuring systems.

Wherever voltage or resistance ratios are more important than absolute values, Model 11 provides fast measurements to an accuracy of .05%.

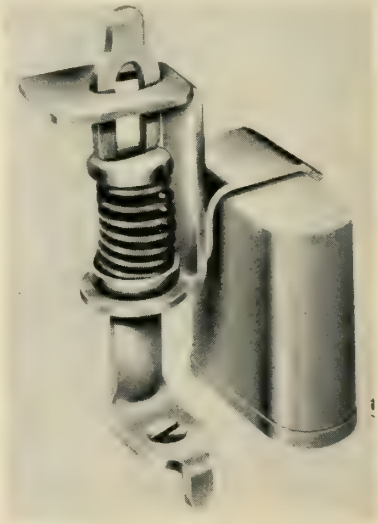
Model 11 has self-contained mecury cell and standard cell and provides voltages in two ranges, 1 v and 10 v.

Circle No. 246 on Subscriber Service Card.

CRYSTAL CLIP

A line of crystal retainers made from type 302 stainless steel has been developed by Birtcher Corp.

Designed to hold nearly all popularly used crystals, semi-conductors and other miniature components having similar con-



figurations securely in place under severe shock and vibration.

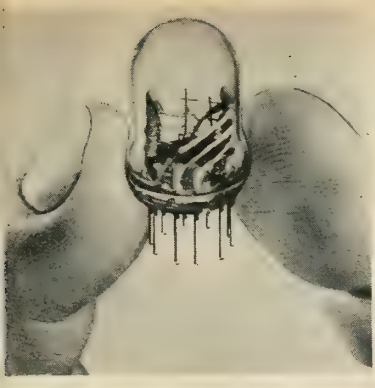
Chassis mounting is accomplished through one screw or rivet and a drilled hole for a positioning tab. Removal of crystal is done through slight upward pressure on the spring-loaded retaining flange which swings out of the way for easy access.

Circle No. 234 on Subscriber Service Card.

MINIATURE READ-OUT TUBE

A miniature, all-electronic device which converts electronic signals directly to readable characteristics has been announced by Electronic Tube Division of Burroughs Corp.

Named miniature NIXIE, the unit is gas-filled, cold cathode, 10-digit, numerical indicator tube having a common anode. The tube utilizes 100 v and operates at



1/8 watt. It measures 6/10 in. in diameter, 3/4 in. high.

Features include rugged construction, simple plug-in stem, perfectly formed figures, controllable brilliance, according to the manufacturer. It is not affected by environmental conditions.

Can be used whenever read-out is required.

Circle No. 244 on Subscriber Service Card.

AUTOMATIC PROGRAMMER

Model 183 Programmer, developed by Sanborn Co., automatically programs operation of Sanborn six-and-eight-channel oscillographic recording systems for analog computer read-out.

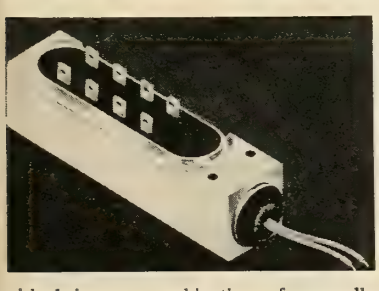
Joint operation of the 156- or 158-5490 Sanborn Console system and the Model 183 Programmer occurs automatically in the following sequence (unless manually terminated): Step 1: recorder turned on; Steps 2 to 16: calibration signal voltages of 0, 100, 20, 10, 5, 1, .2, 0, -.2, -1, -5, -10, -20, -100 and 0 fed to all channels; Steps 17 and 18; dc levels of computer read; Step 19: computer output recorded for predetermined chart length, or as controlled by computer; Step 20: recorder turned off, programmer reset for another cycle.

Circle No. 238 on Subscriber Service Card.

SQUIB-ACTUATED SWITCH

Atlas Powder Co. has developed a squib-actuated switch that has special characteristics attractive to designers and producers of aircraft, missiles and special weapons components.

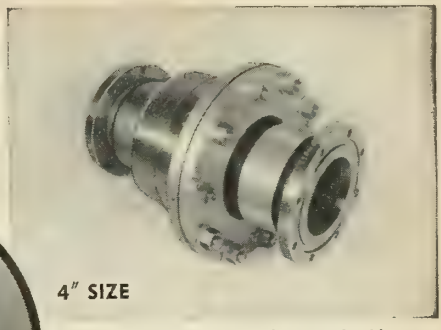
Encased in metal housing, ½ in. x ½ in. x 2 5/32 in., the switch provides four sets of contacts which can be furnished in any combination of normally open and normally closed positions. It is unaffected by vibration of 100 g's amplitude from 20 to 2,000 cycles/sec. and is not damaged by shock acceleration of 15,000 g's in any direction.



Insulation resistance between open contacts at 500 v is 5 x 10^{11} ohms; contact resistance, closed contacts at 1 to 10 amperes, 4 x 10^{3} ohms; current capacity

BARCO FLEXIBLE JOINTS

For Handling High Energy Fuels . . . .



4" SIZE

4" special stainless steel Barco Flexible Ball Joint for handling liquid oxygen.



. . . . . liquid oxygen, white fuming and red fuming nitric acid, and JP 3, 4, and 5 fuel



6" SIZE

180° flanged 6" Barco Ball Joint for use in loading and unloading line handling liquid propellant.

-special designs for LOX and other Missile Fuels

Extensive design and manufacturing experience is yours to call upon at Barco for the handling of special liquid fuels in the aircraft, rocket, and missile industries:

—Flexible Ball Joints for metal loading lines handling corrosive fluids.

—Special flexible joints with leakproof seals for conveying fluids at low temperatures down to −300° F. Also high temperature designs up to +1000° F.

—Special designs resistant to nuclear energy radiation.

Barco joints provide flexibility *unlimited* for piping and tubing. Our engineers will be glad to work with you on special problems and assist with recommendations.

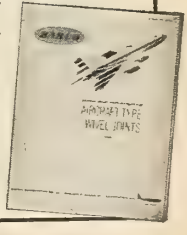
Flexible Hydraulic Lines for Missiles, Aircraft



MISSILE LAUNCHER HYDRAULIC ASSEMBLY

Barco produces high pressure self-aligning swivel joint and tubing assemblies for hydraulic pressures to 4,000 psi, and higher. Also a wide selection of standard and special swivel joints and assemblies for launching and flight gear. Sizes ¼" to 1".

ASK FOR NEW CATALOG 269-A.



BARCO MANUFACTURING CO. *Serving Industry Since 1908* **520F Hough St., Barrington, Ill.**

AIRCRAFT DIVISION

Circle No. 56 on Subscriber Service Card.



Double sealing . . . inorganic construction make

New 'Diamond H' Series S Relays Doubly Dependable

in dry circuits

Separately sealed coils isolated from completely inorganic switches within their hermetically sealed cases make these new "Diamond H" Series S aircraft type 4PDT relays supremely reliable in dry circuits.

Physically and electrically interchangeable with "Diamond H" Series R relays, widely used in guided missiles, computers, jet engine controls, automation control systems and similar critical applications because of their broad range of performance characteristics, Series S relays will permit intermixing of dry and wet circuits safely.

Contacts are specially processed and cleaned before assembly; subsequent contamination from gases off the coil insulation is prevented by the coil seal. The switch mechanism has been simplified and is completely inorganic to eliminate other possible causes of malfunctioning.

Standard contact ratings include 30 V., D. C.; 115 V., A. C.; 2, 5, 7-1/2 and 10 A., resistive; 2 and 5 A., inductive, with special ratings available to 350 V., D. C., 400 MA, or other combinations including very low voltages and amperages, or amperages up to 20 for short life requirements. Coils are available with resistances of 1 ohm to 50,000 ohms. Operating time of 24 V. models is 10 ms. or less; dropout less than 3 ms.

Vibration resistances range from 10-55 cycles at 1/16" double amplitude to 55-2,000 cycles at 20 "G"; operational shock resistances to 50 "G" plus, and mechanical shock resistance up to 1,000 "G". Nine standard mounting arrangements, plus a ceramic plug-in socket, are available. The unit displaces only 1.6 cubic inches, excluding terminals.

"Diamond H" engineers will be happy to work out a variation to meet your specific requirements. Tell us your needs . . . or write for bulletin on new "Diamond H" Series S relays.

THE HART MANUFACTURING COMPANY

161 Bartholomew Avenue, Hartford, Conn.

Circle No. 57 on Subscriber Service Card.

of contacts, continuous, 10 amperes; for 100 millisecond, 100 amperes. Actuation time of switch: carbon bridge, less than 1 millisecond; wire bridge 2-4 milliseconds.

Circle No. 247 on Subscriber Service Card.

DIGITAL TACHOMETER

A digital tachometer offering precise rotational measurement for instrumental applications for missiles is being manufactured by Nacimco Products, Inc.

Accuracy of the instrument is limited only by read-out method employed, and can be better than .001 rpm, with a scale of zero to 10,000 rpm. Output can be by sharp pulse or sine wave with signal set one to 100 per revolution. The tachometer is available with either single-ended or



feed-through shafts, for mounting on drive pads.

Instrument is said to be extremely rugged and has proven highly reliable in wide a range of applications.

Circle No. 245 on Subscriber Service Card.

SILICONE BLANKET

Hewitt-Robins, Inc., has developed a 6 ft. x 30 ft. silicone blanket for use in high temperature vacuum bonding of epoxy resins. Blanket will permit bonding of larger surfaces than previously possible.

Blankets are made in standard thicknesses of 1/16 and 5/16 in. but can be made in heavier gauges on special order. They can withstand operating temperatures up to 500°F and have good heat aging properties, high tear resistance, high elongation, high tensile characteristics and good recovery.

Circle No. 243 on Subscriber Service Card.

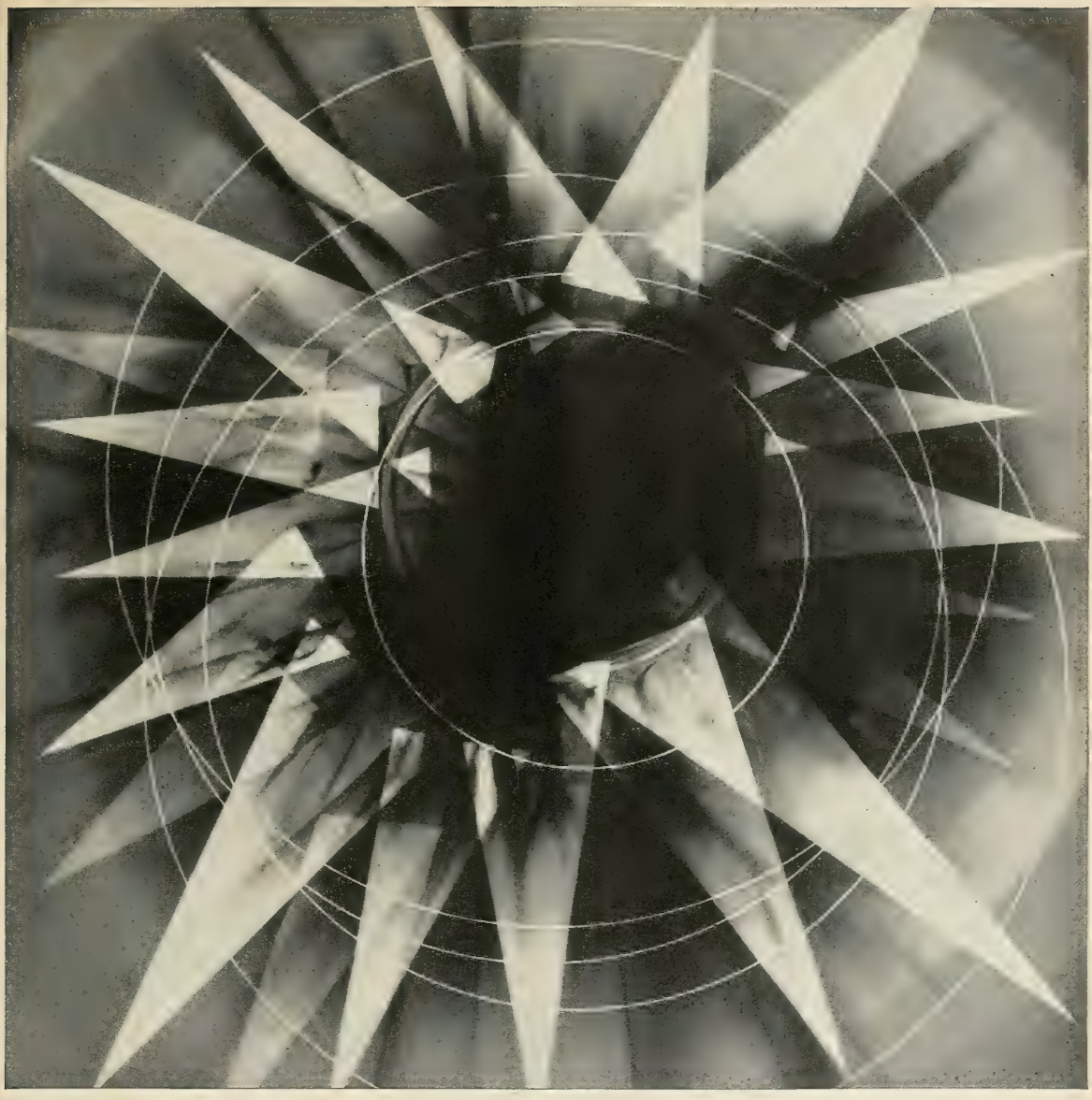
SILICONE RUBBER

Two silicone rubbers have been developed for service at temperatures in the range of 600°F by Dow Corning Corp.

Identified as Silastic 6535 and Silastic 2071, both are said to be primarily cloth-coating stocks, characterized by excellent bond strength, low compression set, and a high degree of resistance to reversion under clamps.

Silastic 6535 is a liquid dispersion type. Vulcanized, it retains resilience from 600°F to -178°F.

Silastic 2071 is designed especially for calendering, although it is also suitable for molding or extruding. Properties



breaking the barriers
with Utica Vacuum Metals

Now that supersonic flight has become routine, today's challenge lies in developing *metals* and *means* of cracking the thermal barrier.

The metals problem has already been partially solved by superalloys produced through Vacuum Melting. This process, as developed by Utica, has yielded such super refractory alloys as Udimet 500—a clean, pure alloy combining unsurpassed stress-rupture life with superior high tensile strength in the 1200° F to 1800° F range. *At 1600° F, Udimet 500 has a tensile strength of over 100,000 PSI.*

In addition to the development of new and superalloys, Utica specializes in upgrading the quality of existing alloys.

VACUUM MELTING
provides these properties

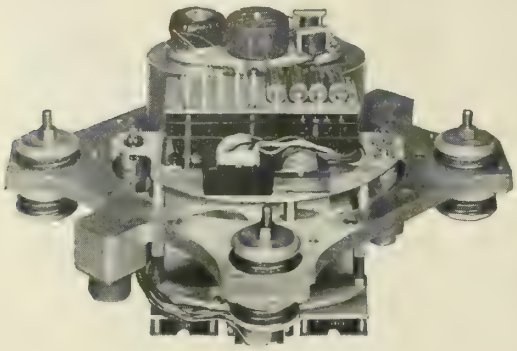
- High temperature corrosion resistance
- Increased ductility
- Extreme cleanliness
- Precise chemical control
- Longer stress-rupture life
- Increased tensile strength
- Better fatigue resistance
- Greater yield strength
- Greater impact resistance
- Greater creep properties

UTICA METALS DIVISION OF KELSEY-HAYES

UTICA DROP FORGE & TOOL DIVISION — KELSEY-HAYES CO., UTICA 4, NEW YORK

SCIENTISTS AND ENGINEERS:

DESIGN ADVANCED AIRBORNE CONTROL SYSTEMS LIKE THIS!



BRAINS FOR THE VANGUARD ROCKET DESIGNED BY HONEYWELL AERO!

Here is the first photograph of the guidance reference system for Project Vanguard. Designed and built by Honeywell Aero, this sensitive electronic mechanism must keep the finless rocket on course despite vibrations and accelerations hitherto unknown.

Many of the components of this Vanguard Guidance Reference System have possible inertial applications.

And Honeywell's development of precise gyros, accelerometers and computers makes Honeywell the leader in this advanced new field of inertial guidance.

FUTURE ACCOMPLISHMENTS! Inertial guidance is just one of the many exciting areas in which Honeywell scientists and engineers are making new advances. 280 research and development projects now in progress are in such fields as:

Inertial Guidance • Flight Control Systems • Liquid Measurement Systems • Vertical, Rate and Integrating Gyros • Digital and Analog Computers • Jet Engine Controls • Air Data Computers • Bombing Computers • Transistor Amplifiers • Instrumentation.

Career Opportunities: Each of these projects offers exceptional career opportunities for capable engineers and scientists.

And, at Honeywell, your advancement will be aided by these factors: *Honeywell Aero is growing;* Engineering personnel, tripled since 1951, is still growing faster than the avionics industry average. *Honeywell engineers work in small groups;* you guide your own development team, supervise your own project. *Honeywell Aero is engineer-managed;* supervisors understand your problems, know your value, help you move ahead.

WRITE TODAY!

For more information concerning these opportunities or for a personal interview, send your résumé to: Bruce D. Wood, Technical Director, Dept. TA19D, Honeywell Aero, 1433 Stinson Boulevard, Minneapolis 13, Minnesota.

Honeywell

Aeronautical Division

after 24 hours in a circulating air oven at 600°F include a Shore A Scale hardness rating of 63, a tensile strength of 700 psi, and 200% elongation.

Circle No. 227 on Subscriber Service Card.

HEAVY-DUTY CIRCUIT BREAKER

A weatherproof, precision-type, heavy-duty circuit breaker for applications demanding precision, high shock and vibration resistant units, is in production at the Spencer Thermostat Division of Metals & Controls Corp.

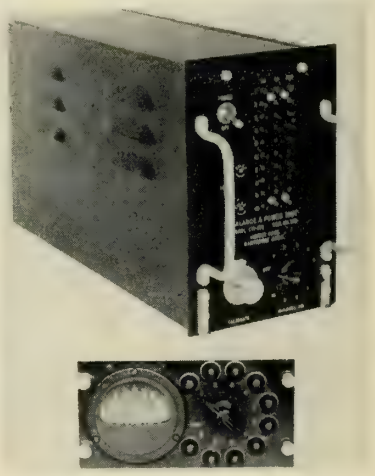
Breakers weigh 7½ oz., are compact and have snap-acting disc actuating elements. Ratings range from 105 to 200 amperes.

Automatic and manual reset types operate at predetermined current overload. Excess current passing through the disc causes it to heat to tripping temperature and snap into reverse curvature, opening the contacts and breaking the circuit. In automatic reset types, disc reverts to original curvature after short cooling time.

Circle No. 233 on Subscriber Service Card.

TEMPERATURE MONITOR

Arnoux Corp. is marketing a critical temperature monitor which is powered and operated entirely by magnetic amplifier circuitry and simultaneously monitors up to 10 channels of temperature.



Model CTI-10D has adjustments for balance and sensitivity which enable each channel to be set for any desired critical temperature range and trip point. This point may be set accurately to within 1% of the operating range established.

Power requirements are 105-125 v, 380-420 cps, 25 watts. Unit includes warning panel, 5¾ in. x 3 in. x 3 in.; balance and power unit 5⅛ in. x 9¼ in. x 19 in. Weight of complete unit 15 lbs.

Circle No. 242 on Subscriber Service Card.

DYNAMOMETER

Development of a dynamometer to completely test torque and speed characteristics of shaded pole motors and induction motors has been announced by Magtrol, Inc.

The unit operates on the principle of feed back torque control such that when a decrease in speed is detected by the tachometer generator of the unit, a corresponding decrease in load torque is instantaneously effected and the motor stablilized in any portion of the curve. Motors may be tested for a maximum

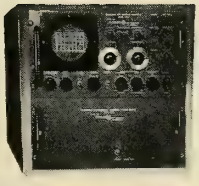
PANORAMIC

TELEMETERING INSTRUMENTS

Use these proven Panoramic Telemetering Instruments *BEFORE, DURING* and *AFTER* tests to detect cause/effect of deviations, pinpoint difficulties, make corrections in time to avoid expensive system failures. The specific functions of these instruments in checking both the airborne and ground station equipment are briefly tabulated here.

provide a simple, reliable, almost instantaneous method of checking FM/FM Telemetering System operation

PANORAMIC TELEMETERING INDICATOR



MODEL TMI-1 Panoramic's Telemetering Indicator was specifically designed for checking FM/FM telemetering systems. In just one second it automatically provides a visual display of the frequency and amplitude of composite signal components. Scans spectrum logarithmically from 350 cps to 85 kc, or linearly, any 100 cps to 20 kc segment centered anywhere between 400 and 70,000 cps. Permits measurement of spurious products down 40 db. Features 20 db linear and 40 db log amplitude scales; 2 mv full scale sensitivity; automatic optimum resolution.

USES: Monitor entire subcarrier spectrum; measure and analyze subcarrier distortions; investigate hum, noise, microphonics and interference; detect channel spillover; set up subcarrier pre-emphasis; calibrate or linearize subcarrier oscillators (when used with Panoramic Frequency Calibrators); monitor magnetic tape re-recordings.

PANORAMIC ANALYZERS FOR RF SIGNALS



MODEL SA-3 Panadaptor, in three different types, is ideal as a tuning aid to permit rapid tuning-in of signal and detection of adjacent channel interference.

Type T-3000-CI is designed to operate with receivers having 21.4 mc IF.

Types T-2000 and T-3000 are designed to operate with receivers having 30 mc IF.



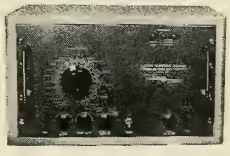
MODEL SB-8b Panalyzor, in two different types, analyzes composite RF signal. Is used to set up deviation of RF carrier and to analyze sideband structure of FM'd carrier.

Type T-1000-CI is designed to operate with receivers having 21.4 IF.

Type T-200-R is designed to operate with receivers having 30 mc IF.

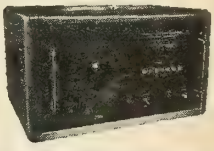
PANORAMIC TELEMETERING FREQUENCY CALIBRATORS

Three models, designed to meet the needs of different application requirements, provide precise frequency calibration points for all RDB channels conveniently . . . rapidly.

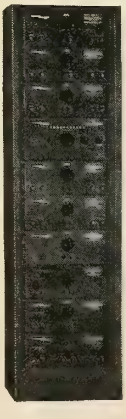


USES: Calibrate or linearize subcarrier discriminators; provide a precise frequency source for date reduction; calibrate or linearize subcarrier oscillators (when used with Panoramic Telemetering Indicator).

MODEL TMC-1 Panoramic's Telemetering Subcarrier Deviation and Three Point Calibrator sequentially furnishes upper limit, center and lower limit frequencies channel by channel. (Automatic switching with 20-second dwell per channel available on request.) Limits are ± 7.5% for all channels and ± 15% for upper five. Other limits optional. Frequency accuracy 0.02%. Built in channel selector automatically establishes proper center frequency and sweepwidth in companion Model TMI-1 to enable, through visual comparisons of subcarrier oscillator frequencies and corresponding calibrator frequencies, rapid set-up or check of maximum deviation limits and center frequency of subcarrier oscillators.



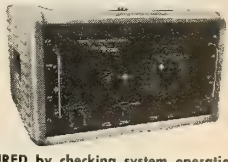
MODEL TMC-307 Panoramic's Seven Point Calibrator sequentially furnishes seven equally spaced frequencies per channel with an accuracy of 0.02%. End limits ± 7.5% for all channels and ± 15% for upper five channels. Other end limits and spacings can be furnished as required. Channel and frequency point switching may be either manual or automatic. On automatic, minimum dwell period is 10 seconds per channel.



MODEL TMC-211 Panoramic's Simultaneous Eleven Point Calibrator differs markedly from the TMC-1 and TMC-307 in that it provides 11 equally spaced frequencies having a 0.002% accuracy, for **all** channels **simultaneously** within the ± 7.5% or ± 15% limits. On automatic, switching of calibrating frequencies is controlled synchronously and cycling time is adjustable from ¼ to 8 seconds per frequency point. All channels can be sampled in as little as 2¾ seconds. Synchronization may be turned off and any channel calibrating frequencies may be selected manually. The instrument may also be remotely controlled through land wires making possible its use at a central station from which various subcarrier channels may be diverted to different locations.

PANORAMIC TELEMETERING CHANNEL SELECTOR

MODEL CHS-1 Panoramic's Telemetering Channel Selector is a companion instrument to Model TMI-1 automatically establishing the correct center frequency, sweepwidth and resolution of any of the individual subcarrier channels selected for display on the screen of the TMI-1. An internal signal switcher permits alternate display of subcarrier vs. external calibrating markers, available from the TMC-307, TMC-211, or other source, for visual comparison of linearity or spread of subcarrier.



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Be SURE of the accuracy of your telemetering system . . . be ASSURED by checking system operation with Panoramic Telemetering instruments. Write, wire, phone TODAY for complete details and catalog sheets. A Panoramic Applications Engineer is available to work with you on your special problems.

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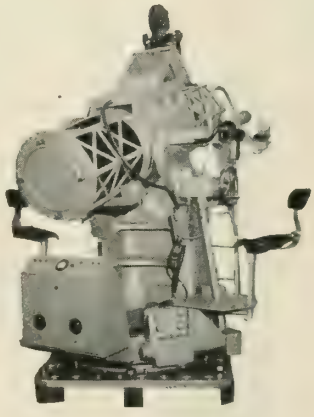
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Circle No. 59 on Subscriber Service Card.



speed as low as 100 rpm with no additional controls or adjustments necessary.

Seven dynamometers with torque ranges from 750 oz.-in. to 1 oz.-in. full scale may be obtained. Tachometer generator can be supplied to indicate speed up to 8,000 by 1 rpm increments, or 30,000 rpm by 10 rpm increments.

Circle No. 239 on Subscriber Service Card.

MINIATURE RF CABLE CONNECTORS

Dage Electric Co., Inc., has introduced a sub-miniature series of RF coaxial cable connectors, designated DM and including 12 different groups of jacks, receptacles and adapters.

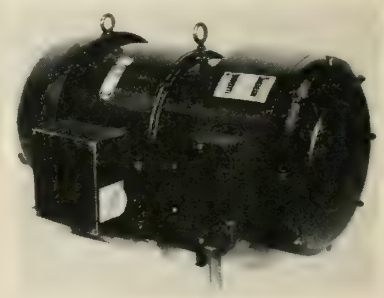
DM connectors are half the size of BNCs, yet can withstand a cable pull of better than 50 lbs. Twelve polarities—one for each group of connectors—prevents wrong connections. Bayonet locking meets MIL-C-5015 specs., provides vibration proof coupling. Teflon insulators permit use over wide range of temperatures with low electric loss.

Circle No. 250 on Subscriber Service Card.

POWER SUPPLY

A lightweight 400-cycle power supply designed to meet military environmental specifications has been developed by Georator Corp.

Unit delivers 400-cycles, 3-phase, 120/208 v, 15 kva continuous, 22.5 kva for short period overloads. Totally enclosed fan-cooled construction is utilized,



use of light metals and "Nobrush" design holds weight within 500 lbs. for complete motor-generator combination.

Dimensions 36" x 19" x 21". Motor operates at 1,800 rpm from standard 220/440 v, 3-phase, 60-cycle supply.

Circle No. 240 on Subscriber Service Card.

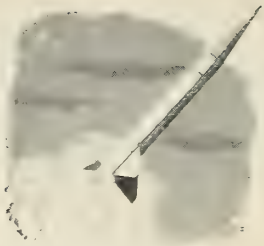
PRESSURE-OPERATED VALVE

Hydromatics, Inc., is producing 8-in. ball-type control valves for high pressure systems up to 2,000 psi and temperatures to 225°F.

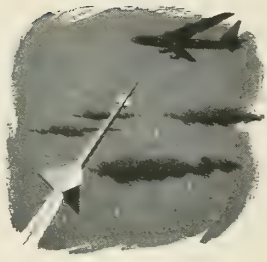
Controlled by pressure actuated operator, valves are said to have rapid re-



Typical assortment of missile batteries engineered and manufactured by Exide.



Surface to surface



Surface to air



Air to air



Air to surface

Exide missile battery program aims at giving you the battery you need, when you want it, with the maximum assurance of reliable performance

Behind the Exide Missile Battery Program lie the full engineering resources of the Exide Laboratories. Engineers in the Missile Applications Section concentrate exclusively on silver zinc missile batteries designed for applications requiring maximum power with minimum weight and space. At their disposal is the extensive knowledge and background of colleagues working in a wide variety of research and engineering fields related to missile batteries.

Benefit from Exide's experience and facilities—unduplicated by any other battery maker in the world. You are invited to submit your auxiliary power requirements and problems to us for study and evaluation by our engineering staff. Exide Industrial Division, The Electric Storage Battery Company, Philadelphia 2, Pa.

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what's YOUR POWER need?



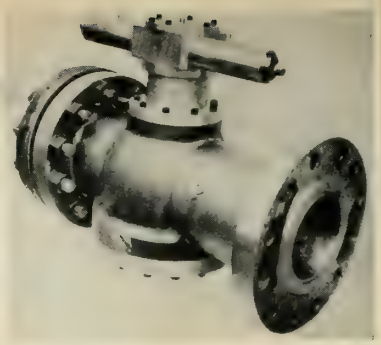
1. M series-100 Volt to 400 Volt PIV - .5 Amp. DC
2. L and LF series-100 Volt to 400 Volt PIV - 1.5 to 5 Amps. DC
3. N series - 50 Volt to 400 Volt PIV - .5 to 1 Amp. DC
4. P series - 50 Volt to 400 Volt PIV - 1.5 to 5 Amps. DC
5. Q series - 50 Volt to 400 Volt PIV - 7.5 to 15 Amps. DC
6. SM series - 800 Volt to 2800 Volt PIV - .325 to .450 Amp. DC
7. R series - 50 Volt to 200 Volt PIV - 20 Amps. DC
8. S series - 50 Volt to 200 Volt PIV - 35 Amps. DC
9. V series - 50 Volt to 200 Volt PIV - 100 Amps. DC
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Circle No. 61 on Subscriber Service Card.



sponse and capable of 2 full travel cycles/sec., or 10 cycles/sec. through any 10% portion of a full stroke.

Overall valve envelop is smaller than any unit previously available for full flow operation at high pressures. May be used with wide range of liquid or gas media.

Circle No. 237 on Subscriber Service Card.

PRESSURE-FILLED "O" RINGS

Development of pressure-filled metal "O"-Rings, which improve sealing characteristics at elevated temperatures and provide increased resilience with greater flange deflection, has been accomplished by Advanced Products Co.

Standard .010 stainless-steel "O" rings are filled with gas at various pressures ranging from 500 to 3,000 psi at room temperature. Internal gas pressure offsets the inherent loss of metal's strength at elevated temperatures.

Missile and other applications requiring operating temperatures above 1,000°F are principal uses for the rings. Rings are made with variations in pressure filling, silver plating, Teflon coating and use of special metals such as Inconel X to meet specific requirements.

Circle No. 236 on Subscriber Service Card.

TIME DWELL SERVO VALVE

Unit designed to convert electronic signals into control forces for missiles, drones or aircraft has been introduced by AiResearch Manufacturing division of Garrett Corp.

Weighing 1¼ lbs., the unit is known as a time dwell servo valve and serves as a link between a missile's electronic computer and control surface actuators. It converts electric signals into hydraulic forces.

Hydraulic oil flows can be regulated from 1/10 to 5 gal./min. at pressures from 750 to 4,000 psi.

A spool and body assembly controls quantity and direction of oil flow to an actuator and a torque motor converts electrical signals into forces to activate the valve spool.

Circle No. 249 on Subscriber Service Card.

MINIATURE PISTON-TYPE MOTORPUMP

Vickers, Inc., is producing a line of miniaturized motorpumps for use in missile systems.

Typical unit, Model AA-19054, delivers .84 gpm at 7,400 rpm and 1,000 psi. Hydraulic pump weighs 1 lb., and electric motor 7 lb. Overall length of both pump and motor is 9 15/16 in.

Starting torque is less than 10% over maximum running torque. High pump efficiency and low starting torque permit use of smaller, lighter motor. Pump

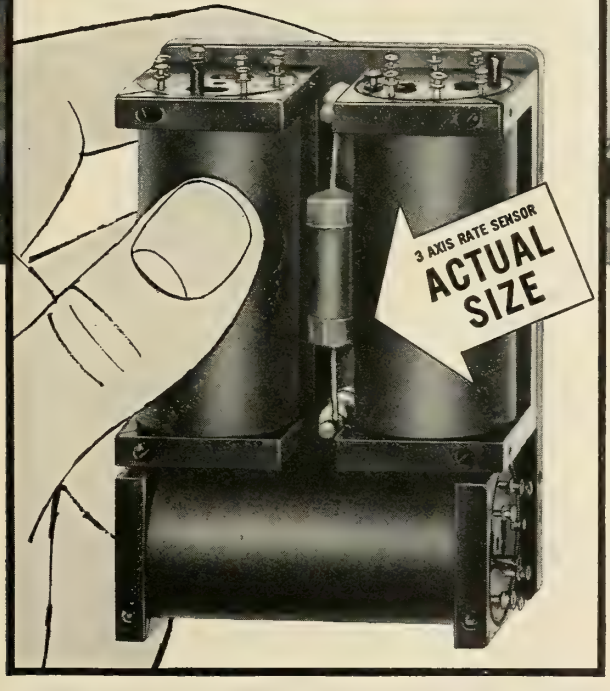
In Control–with U. S. TIME GYROS



Poised on their launchers, the Navy's Terrier guided mi...
Official U. S. Navy photograph.

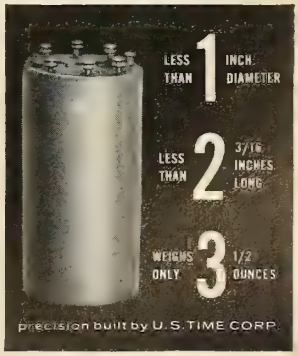
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High Temperature and Moisture Resistant Electrical Cable. Lewis "EXFLEX" Cable, single and multi-conductor, superior for circuits on hinged or pivoted parts. Resistant to abrasion and temperaures to 500°F.

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with nickel-chrome conductor and laminated insulation for operation at 500°F. extensively used by central stations to maintain proper temperatures in pipe lines exposed to wide variations in ambient temperature.

GLASS & ASBESTOS INSULATED HEATING CABLE...

with stainless steel braided shield for special high temperature applications, used by atomic energy facilities.

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with segregated circuits individually shielded, and with over-all shielding or with special shielding and jacketing.

FIRE-RESISTANT AND HIGH TEMPERATURE RESISTANT CABLE...

for circuits required to operate in 2000°F. flame for fifteen minutes. Excellent for fire-detector circuits and for use in temperatures up to 600°F.

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By utilizing and combining the various qualities of fire, heat, abrasion and moisture resistance of asbestos, glass, silicones and Teflon*, we have developed many special wires and cables for avionic and electronic applications. We invite inquiries for cables and wire constructed to customers' specifications for special applications.

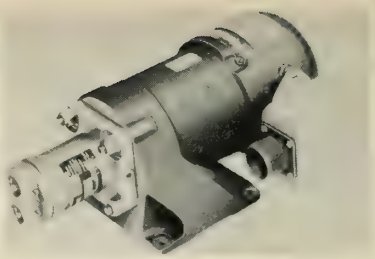
* DuPont Trade Mark

the LEWIS ENGINEERING COMPANY

WIRE DIVISION

NAUGATUCK, CONNECTICUT

Circle No. 63 on Subscriber Service Card.



efficiency reduces current drain, and ability to operate at high speeds permits direct drive. Motor is 28 vdc unit rated at .84 hp. It has radio noise filter and is explosion proof.

Circle No. 241 on Subscriber Service Card.

RECORDING SYSTEM

A Series 3,000 multi-channel magnetic tape recording system featuring a 300 kc band width is being manufactured by the Recordata Division of American Electronics, Inc.

Featuring unusual versatility, extreme accuracy, single switch for the selection of six speeds, and modular construction, the system is said to simplify all recording operations.

The system accommodates reels up to 14 in. as standard equipment and may be ordered to handle 19-in. reels. A single switch on the front panel selects any of the six standard speeds up to 60 in./sec. eliminating the need for changing of belts, pulleys, etc.

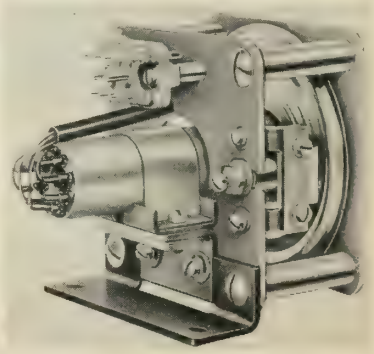
Tape transports are available which accommodate ½, ¼, or 1-in. tape. Tape guides may be easily interchanged. Backlighted control buttons, on the primary panel face, control high-speed fast-forward and rewind functions, record, playback and stop operations.

Convenient module housings provide plug-in facilities for record and playback amplifiers. By plugging the proper modules, instant selection of Direct FM or PDM recordings or playback in any combination can be achieved.

Circle No. 264 on Subscriber Service Card.

PRESSURE TRANSDUCER

Fischer & Porter Co. is producing a pressure transducer for use in data reduction systems. The device converts a 3 to 15 psi signal to ac millivolts directly propertional to pneumatic input.



When pressure is applied to the sensing element of the transducer, the results ing movement of an expandable capsule displaces an armature which induces opposing voltages in twin secondary coils. This voltage is linearly proportional to the pressure input. The output may be used

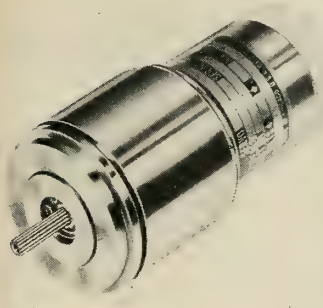
to position an indicator, recorder or control device. Accuracy of the F&P pressure transducer is high 0.25% of the full scale.

Circle No. 266 on Subscriber Service Card.

MOTOR GENERATOR

G-M Laboratories, Inc. has developed a new size 18 motor-generator in which the maximum rms null voltages are 13 millivolts total and 8 millivolts fundamental.

The motor and generator are the equivalent of the BOURD Mark 16.



Motor and generator are combined in an assembly having a single shaft. Motor has a diameter of 1.750 in. and is designed for operation on 400 cycles with a stall torque of 2.35 oz. in. Customary voltages are 26 v or 115 v on the fixed phase, and 26 v, 115 v, or 230 v on the control phase. Other voltages can be provided if needed.

The generator is 1.5 in. in diameter and is designed for operation on 400 cycles.

Circle No. 265 on Subscriber Service Card.

SHAFT POSITION TRANSMITTER

A highly accurate shaft position transmitter having infinite resolution and a null point at the center of rotation has been developed by engineers at G. M. Giannini & Co., Inc.

Designated Model 58175S-5, the instrument consists of a standard three-turn, slide-wire Spiralpot potentiometer which has incorporated within its case fixed resistors wired in a bridged circuit. One leg of the bridge is shunted with the variable section, and output can be read on a sensitive light beam galvanometer. Linearity over ±360° rotation is about ±0.11%. Over the entire ±540° range linearity is ±0.37% or better.

Physical configuration is identical to the Giannini Model 85175 Spiralpot which has a bushed mounted back anodized aluminum case 1.5 in. in diameter by 1.5 in. long. The precision ground, corrosion resistant shaft is supported in miniature ball bearings and an indexing pin provides for panel alignment.

Circle No. 260 on Subscriber Service Card.

SUB MINIATURE CONNECTOR

Automation-Engineering Corp. is producing a sub miniature snap-lock coaxial cable connector and mating receptacle in 50, 75 and 95 ohm sizes. Plug is spring loaded and snaps into position to engage special receptacle firmly. Plug cannot be removed by pulling on the cable, or by vibration, but only by sliding the knurled sleeve toward the cable end.

Connectors will withstand temperature range of —70°F to 550°F and shock of 100 g's on any axis. Vibrations at 5 g's from 10 to 20,000 cycles.

Circle No. 261 on Subscriber Service Card.



Lockheed MISSILE SYSTEMS DIVISION WAS — on how to join thermocouple materials ranging from 1 to 25 mils to .020 steel, copper and aluminum. They succeeded with the help of a Weldmatic stored-energy welder . . . which may be the answer to your problem, too. *Write for complete literature.*

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INDUSTRY SPOTLIGHT

By Joseph S. Murphy

Lawmakers Censure Guided Missile Program

The military guided missile program is wasteful, duplicatory, poorly coordinated and badly managed, according to the Surveys and Investigations Staff of the House Defense Appropriations Subcommittee.

The staff submitted a 200-page report on the missile program to Subcommittee Chairman George Mahon (D-Tex.) at the outset of hearings on the Defense Department's request for $38.5 billion in new money for fiscal 1958. While the report itself was classified and therefore withheld from the record, a substantial portion of its findings were suggested by the questions of Rep. Mahon and his colleagues.

One of the principal things which apparently bothered the subcommittee's staff was the decision to go ahead with the Northrop *Snark* intercontinental missile while failing to request adequate support for North American's ramjet intercontinental *Navaho*.

"Our investigative staff has reported the Special Assistant for Guided Missiles (then Eger V. Murphree) termed the *Snark* program a questionable one," Mahon said. "The committee was advised that Gen. Curtis LeMay, Strategic Air Commander, under whose command the *Snark* will function, has frequently and consistently favored its cancellation . . . It appears to the committee that available dollars might be more profitably used for the more advanced weapons such as the *Navaho* . . ."

Reuben Robertson, Jr., former Deputy Defense Secretary, responded to the criticism with a stout defense of the *Snark*. He praised the accuracy of the turbojet missile, declared that it is firmly scheduled to go into operation with SAC and hinted that the *Navaho* will be dropped entirely. "We view the *Snark's* and *Navaho's* approach in the air-breathing intercontinental group quite similar to the *Thor* and *Jupiter* competitive situation," Robertson said. "One of them is going to win that race and should be put into inventory."

Other staff criticisms which filtered through the interrogation of witnesses:

1. The USAF *Bomarc* interceptor missile is overly vulnerable to jamming and is too expensive in relation to its contribution to national defense. (First production contract for the Boeing missile was announced last month.)

2. One of the outstanding weaknesses in the military missile program has been the failure of the Defense Department to have an adequate organization for the evaluation of military missile projects. Too little use has been made of the Pentagon's Weapon Systems Evaluation Group.

3. Duplication exists in many areas, including the *Thor-Jupiter-Polaris* IRBM program, the *Atlas-Titan* ballistic missile program and the *Nike Hercules* and *Talos* air defense program.

4. Efforts by the military services to establish anti-ballistic missile programs are not coordinated.

5. The Navy wasted millions on the Army's *Jupiter* IRBM before striking out on its own with the *Polaris* Fleet Ballistic Missile.

6. The *Nike I* is not an effective weapon and introduction of the *Nike Hercules* has been delayed through failure to utilize the Douglas Santa Monica plant as a prime source in addition to the Charlotte Ordnance Plant, also operated by Douglas.

The former Deputy Defense chief offered a rebuttal for most of the charges, plus some criticism of his own for the way the subcommittee's staff put together its report. Most of the duplications which now exist were ordered deliberately as insurance against technical setbacks, he observed. Exceptions are the Navy *Regulus* and the Martin *Matador*; latter was to be abandoned, but the decision was reversed when the Korean War developed, he said.

Robertson also said the staff was

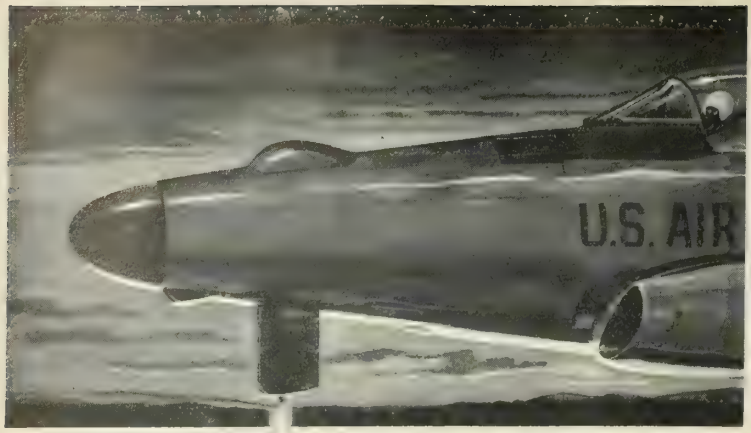
A "confidential" presentation of the Air Force's overall missile procurement program for fiscal 1958 slipped into the published record of the USAF hearings. Reason for the security label was the fact that it included an exact breakdown of the ballistic missile program. Apparently it was overlooked by the censors when they cleaned classified information out of the record.

The figures show that almost half the total of missile procurement funds requested by the Air Force for next fiscal year will finance the *Atlas-Titan-Thor* ballistic missile development program. The airmen have programmed $955.7 million for the ICBM-IRBM projects, compared with $994.8 million for all other missiles. Included are comparisons with fiscal 1957 and 1956 (in millions of dollars):

	Fiscal 1958	Fiscal 1957	Fiscal 1956
Ballistic missiles	$676.9	$659.4	$267.0
Ballistic missile spares	37.5	15.7	11.6
Ground handling equipment	234.6	203.6	29.3
Center support	6.7	3.7	0
Subtotal	$955.7	$882.4	$307.9
Other missiles	737.9	1,016.4	551.8
Other missile spares	68.2	81.1	32.6
Ground handling equipment	188.7	188.9	105.1
Subtotal	$994.8	$1,286.4	$689.5
Total	$1,950.5	$2,168.8	$997.4

The procurement program does not include outlays necessary to provide contractors with the manufacturing, development and testing facilities they need for the ballistic projects. USAF is seeking $13,500,000 for these facilities in fiscal 1958, down sharply from the $84,500,000 voted last year and the $65 million voted in fiscal 1956.

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Kentucky Windage at 650 MPH?

"Kentucky windage" is fine for an oldtime squirrel shooter at 60 yards. But how do you compute cross-wind allowance for high-speed jets aiming at fast-moving flank targets?

The compilation of firing tables required for cross-wind cannon firing is typical of the complex problems facing modern weaponeers. The special abilities of Thieblot Aircraft Company, a division of Vitro Corporation of America, in designing and manufacturing aircraft components and ordnance have made it a key member of the Army-Air Force team working on this difficult ballistics problem.

Thieblot's contribution was the design of a new ballistics data nose. Only a foot longer than conventional fighter noses, it carries a 20 mm. cannon with mount independent of the aircraft motion, four high-speed cameras, radar, and electronic equipment. With auxiliary ground controls this equipment "fixes" projectiles in time and space. This leads to greater protection for bombers and other combat aircraft through more accurate flank fire.

Thieblot Aircraft has also designed purge mat systems for jet trainers, a boundary layer control system, a nose-wheel steering mechanism, an inflight refueling unit, an escape reel for ditched aircraft and other equipment.

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arbitrary in its recommendations to cut off projects of many years' duration, that it gave undue weight to low-level staff studies as opposed to top policy-making points of view in its report, and that there is, despite all the talk of interservice rivalry, a rather extensive interchange of missile information between the services.

Here are the missile high-lights of the appropriation hearings:

Air Force

USAF is currently devoting its anti-ballistic missile efforts primarily to the task of early detection of the so-called "ultimate" weapon. Former Air Force Secretary Donald Quarles said the ICBM could be detected as much as 15 minutes before impact through modification of the SAGE system and the early warning radar lines. This scant warning could reduce casualties enormously as well as alert the armed forces to retaliation. The job of positive defense against the ICBM is much more difficult, and its creation would probably lag several years behind the introduction of the ICBM itself, Quarles said. He estimated the cost of an effective anti-missile defense as "comparable" to the cost of the ICBM itself. Maj. Gen. Bernard Schriever, chief of ballistic missile development for the USAF, underscored the difficulty. "There is . . . no doubt in anyone's mind that it (the anti-missile) is a very difficult technical problem, and that is only to take care of the most unsophisticated type of a ballistic missile nose cone."

Air Force will put money into at least two Navy airborne missiles. It will buy the infra-red *Sidewinder* air-to-air missile from the Bureau of Ordnance for its Lockheed F-104A day interceptor. It also expects to put the Navy-developed Martin *Bullpup*, an air-to-surface missile.

Procurement of the Douglas MB-1 nuclear air-to-air rocket will climb sharply in fiscal 1958. In addition to buying increased quantities for operational use, USAF expects to purchase more than $19 million worth of the weapons for its mobilization reserve.

USAF appears to have abandoned the idea of putting the Radioplane *Crossbow* (a derivative of the *Firebee* drone) into production. But two new drones, the Q-4 and Q-5, were revealed. Latter appears to be a derivative of the Lockheed X-7 ramjet test vehicle.

Navy

The Fairchild *Petrel* air-to-surface missile has been discontinued and will not be produced any further.

The *Vanguard* satellite launching

system is proving far more costly than the original $20 million estimate. Office of Naval Research has asked a total of $56.4 million for the project to date, including $25 million from the Pentagon Emergency Fund.

Bureau of Aeronautics is requesting $236,800,000 for procurement of missiles and drones in fiscal 1958, while BuOrd is requesting $179,332,000 for missile procurement.

For missile research, BuAer is asking $36,420,000 and BuOrd is requesting $128,300,000, including $68 million for *Polaris,* up $10 million from last year.

Rear Adm. William Raborn, Jr., director of the *Polaris* project, said the Navy's decision to abandon the fleet ballistic missile version of the Army *Jupiter* and proceed with independent development of the *Polaris* FBM will save U.S. taxpayers $500 million. He said the solid-propellant *Polaris* will be a cheaper, safer and better weapon for shipboard use than the liquid-propellant *Jupiter.*

Navy is also requesting $500,000 for advance planning of a nuclear submarine capable of launching the *Polaris* formal request for authorization to build will come next year.

A "major improvement" of the infra-red *Sidewinder* is under development and an improved version of the radar-guided *Sparrow* will go under development soon. Both are air-to-air weapons. A *Terrier II* is under development which will double the range of the present 20-mile ship-launched air-defense weapon.

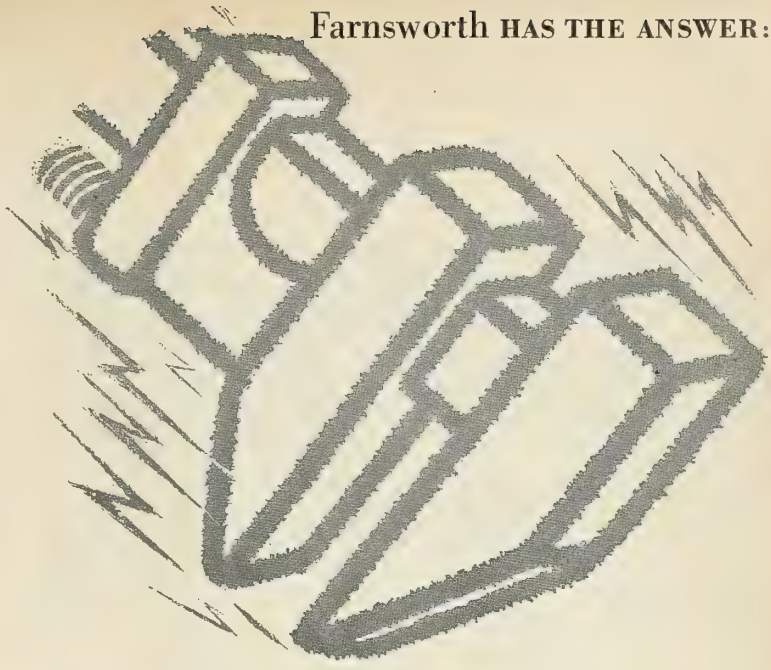
The Marine Corps is contributing funds to the development of the Army's *Hawk* low-altitude aid defense missile. *Hawk* is an outgrowth of Raytheon's *Sparrow III.*

Two new air-launched weapons for use against submarines are in advanced stages of development, and production has commenced on one. A third new ASW weapon has just completed the research phase. The weapons were not identified, but it is believed one of them is the *Lulu,* a nuclear depth charge.

Army

Nike Ajax, the nation's first anti-aircraft missile to go into operational use, has been phased out. The soldiers canceled plans to buy the weapon with funds voted for the current fiscal year, and also dropped orders for 300 *Nike Ajax* placed with 1956 funds. They may drop another 400 *Nike Ajax* from the 1956 program. The money is being diverted to the more advanced *Nike Hercules,* with procurement of the latter transferred from the Douglas-Santa Monica plant to Charlotte Ordnance

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Plant to build up production there as rapidly as possible.

Funds have been requested to support development of the *Talos* during fiscal 1958. This is the shore-based version of the Navy-developed air defense weapon transferred from the Air Force to the Army in the same Pentagon order last November which gave the *Jupiter* to the Air Force. The Army plans to evaluate *Talos* as a possible supplement to *Nike Hercules*.

The Army has given top priority to the development of an anti-ballistic missile. It has requested $12 million to finance study of the problem in fiscal 1958. "We must get on with the job," declared Lt. Gen. James Gavin, chief of Army research.

Corrosion and deterioration have taken their toll of *Nike Ajax* now installed at launching sites. Army is asking funds to rebuild some 4,000 of the weapons. Nitric acid and exposure to the weather have been the chief troubles, but synthetic rubber components like gaskets have also shown signs of deteriorating.

Solar Furnace to Aid Missile Metal Studies

The study of the effects of rapid temperature changes on metals used in missile structures is expected to make the greatest use of a huge solar furnace to be constructed by Air Research and Development Command near Cloudcroft, New Mexico.

The furnace will be the largest in the world and more efficient than the existing one in the Pyrenees Mountains between Spain and France. Completion is scheduled for early 1959. Use of the instrument will be under ARDC'S Holloman Air Development Center.

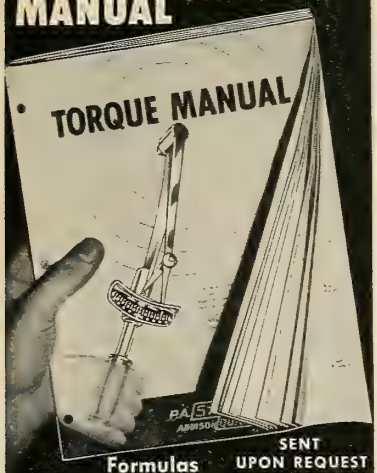
The new furnace is expected to produce temperatures as high as 8,000°F—about 70% that at the surface of the sun. A staff of about 100 will be needed for its operation.

The furnace will be composed of three basic parts: a heliostat, which is the primary sun-reflecting mirror, measuring 130 ft. high and 140 ft. wide; the attenuating shutter, a venetian blind-type device which regulates the amount of sunlight traveling from the heliostat to the parabolic mirror; and, the parabolic mirror which collects the sunlight and concentrates it on the focal spot.

Thiokol Gets Contract

Thiokol Chemical Corp. has received a $790,758 contract for solid-propellant boosters for the Martin *Matador* TM-61B. Work will be done at company's Utah Division at Brigham City.

"TORQUE WRENCH" MANUAL



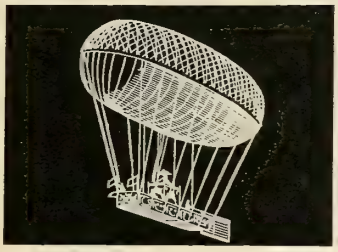
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industry briefs

SIEGLER CORP. reports record sales of $22,688,892 for the nine months ending March 31. This almost doubles the sales figure for the comparable period in 1956.

RAYTHEON MANUFACTURING CO. has taken over management of Navy's plant at Bristol, Tenn., for production of *Sparrow III* missile for which Raytheon is prime contractor. Plant had been used by Sperry-Farragut Co. to produce *Sparrow I*, now in operational use.

THE GARRETT CORP.'s AiResearch Manufacturing division has started construction of a 40,000-sq.-ft. working area to consolidate electronic and pneumatic control activities at Phoenix. Master plan calls for 120,000-sq.-ft. building employing 500 workers.

THE MARTIN CO. has released 50 engineers and transferred another 50 from Baltimore to Orlando and Denver. Moves are results of Air Force cancellation of contract to develop high-speed bomber and failure of Martin to win contract for seaplanes.

BEECH AIRCRAFT CORP. will move its Boulder Division manufacturing operations to Longmont, Colo. Engineering and general offices will stay at Boulder. About 50 of division's 200 employes will move.

RETMA, Radio - Electronics - Television Manufacturers Association board of directors have unanimously voted to change the organization's name to Electronic Industries Association. Proposal will be submitted to membership.

McDONNELL AIRCRAFT CORP.'s employment reached all-time high with the recent hiring of the 25,000th employe. Current employment is five times World War II peak and weekly payroll now tops $2,600,000.

SUMMERS GYROSCOPE CO. is seeking Securities and Exchange Commission registration for 250,080 shares of $1 par common stock to be offered for subscription to current stockholders at rate of two new shares for each five shares held May 31, 1957. Proceeds will be added to working capital and used for general corporate purposes as needed.

RYAN AERONAUTICAL CO. has acquired an assembly plant and a 27-acre site adjacent to Torrance, Calif., Municipal Airport. New facility contains 137,000 sq. ft. of floor space.

AMERICAN BOSCH ARMA CORP. board of directors declared a dividend of 25¢ per common share, payable July 15 to holders of record June 14, and voted the regular quarterly dividend of $1.25 per share on the 5% cumulative preferred stock Series A and B, $100 par value, payable July 1 to stock of record June 14.

FIRESTONE TIRE & RUBBER CO. has received a subcontract from The Martin Co. to develop and test components of the *Matador* TM-61B missile. Work under the contract will be done at Firestone's Defense Research Division and Engineering Laboratory, Monterey, Calif.

RESEARCH ENGINEERING SERVICES CORP., Sandy Springs, Ga., is a newly incorporated firm of aeronautical engineers and research scientists in Atlanta. Principal officers are: president, Willi Jacobs; v. p., Peter Fielding; secretary-treasurer, Erik Sieurin.

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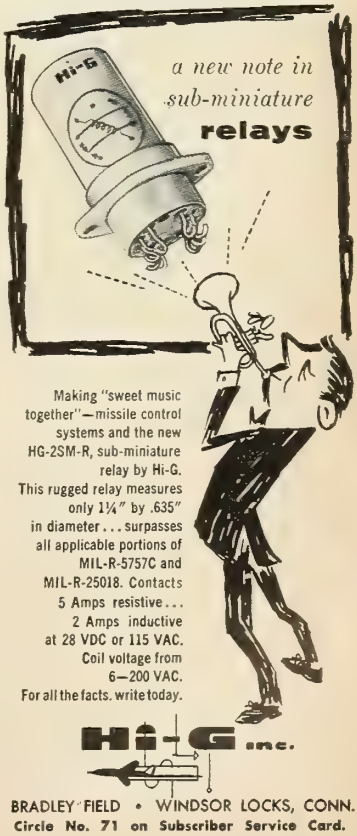
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Kentanium is the name of a family of Titanium Carbides, developed by Kennametal Inc. It is molded from powders into many forms, retains strength and structural integrity at elevated temperatures, and possesses unusual resistance to thermal shock.

Engineers have reported successful use at continuous operating temperatures up to 2200°F, and under intermittent exposures up to 5000°F, where oxidizing atmospheres were combined with abrasion, and the parts were under compressive or tensile loading.

Many grades of this lightweight, exceptionally pure titanium carbide have been developed for various requirements. Kentanium can be extruded and molded into many forms, eliminating difficult machining. More intricate forms are readily machined from pressed slugs. Precise dimensional tolerances are attained by grinding after forms are sintered.

Kentanium is presently serving in bearings, thrust runners and other parts in pumps for handling high temperature liquid metals; blades, wheels, nozzle vanes, and temperature sensing elements for gas turbines and jet engines; bushings, seals and bearings (unlubricated); and other applications at high temperatures. Added information is offered in our bulletin "Kentanium." Send for it . . . and ask Kennametal engineers for added help if you need it to adapt Kentanium to your specific problem. Write KENNAMETAL INC., Latrobe, Pennsylvania.

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Industry Highlights



By Fred S. Hunter

They're back on the beam at Hughes Aircraft's Tucson plant, where the *Falcon* is produced. The five-day week (cut back to four last February) has been restored and most of the 496 employes laid off at the same time have been called back to their jobs. Moreover, Hughes-Tucson now has about 100 openings for workers having special skills. Reports that Hughes spent its own money in making fixes to restore the *Falcon* to its previous high degree of reliability are not confirmed by the company, but may very well be true. Hughes has never hestitated to do this sort of thing at its own expense. The Hughes *Falcon* now has a formidable competitor in the new Douglas MB-1 rocket. But Hughes has new models of the *Falcon*—the GAR-3 and the GAR-4—coming along, too.

•

Liquid oxygen has hazardous characteristics, such as its temperature of minus 297 degrees F, which can damage skin or eyes on contact, but rocket makers have found it creates no special problems if handled properly. At Rocketdyne, they handle it like water around the house—just try not to spill it—and they've never yet had a handling accident.

•

The Douglas MB-1 *(Ding-Dong)* has a tear-drop-like configuration incorporating four fins.

•

First Bay area headquarters of Lockheed's Missile Systems division is no more. It was opened in San Jose in February, 1956, with a handful of employes, built up to a maximum of 290, and diminished as space became available at Palo Alto and Sunnyvale. Lockheed closed its doors the other day after Building 102, the second 96,000 square foot structure at Sunnyvale, became available. The new Sunnyvale building also provided a home for members of the Navy's resident staff, who previously had occupied temporary quarters at Moffett Field. Capt. W. A. Hasler, Jr., formerly chief of the Navy office at the Army Ballistic Missile Agency at Huntsville, Ala., heads up the Bureau of Ordnance Technical Office providing field technical liaison and direction to Lockheed on what is known at Lockheed as the XN project, but which you know as the Polaris.

•

Highest Nike battery in the nation is in the protective ring of 16 guarding the Los Angeles area. It's at 6000 feet on Mt. Gleason.

•

Northrop Aircraft, which has been paying $100 awards to employes for successful referrals of engineers, is now also paying $50 for referrals of needed machinists.

•

Willy A. Fiedler, now on the scientific staff of Lockheed's Missile System division, received a superior accomplishment award—with a $595 check to add to a $300 incentive award check previously received—from the Navy for a new-type dummy missile design he proposed while working at the Point Mugu Naval Air Missile Test Center. The design saved the Navy $300,000.

•

Every now and then Rocketdyne encounters an extra problem getting equipment into the back canyons of the Santa Susana Mountains, where its Propulsion Field Laboratory is located. A pressure vessel weighing 109 tons was a recent example. Took an entire day to haul it the 11½ miles from the Chatsworth rail siding. It also took two 250 hp diesel tractors in tandem. When the Rocketdyne crew tried pulling the low-bed semi-trailer carrying the pressure vessel with one diesel, the front wheels of the tractor were pulled off the ground. Heavy weight of the vessel, tractors and trailer was spread over 48 pneumatic tires.

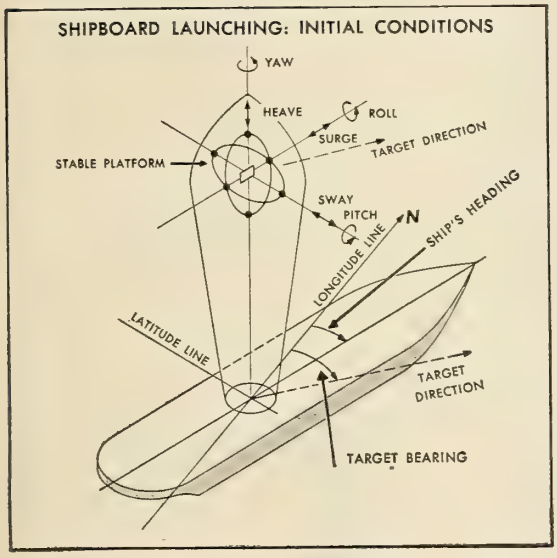
ENGINEERS—SCIENTISTS

GENERAL ELECTRIC SELECTED TO DEVELOP GUIDANCE AND FIRE CONTROL SYSTEMS FOR NEW NAVY MISSILE, POLARIS

New Group Forming as Missile & Ordnance Systems Department of G.E. Adds Navy Project to Nose Cone Development Program.

POLARIS is the most challenging development undertaken by industry for the Navy since the nuclear propulsion program. It is an Intermediate Range Ballistic Missile, whose specifications call for launching capability from both surface vessels and submarines.

PROBLEMS UNIQUE IN MISSILE TECHNOLOGY



The diagram above presents the primary parameters involved in shipboard launching of a ballistic missile in its simplest form.

For Polaris, MOSD must not only surmount these initial conditions but solve fire control problems more complex than heretofore encountered. Pinpoint accuracy in missile guidance is an impressive accomplishment under the most favorable conditions. But how do you achieve it with a missile hurled from a moving platform and aimed at an object approximately 1,500 nautical miles away?

In addition, the Polaris guidance and fire control systems must also operate effectively under the difficult conditions created by submarine launching.

HOW IS MOSD EQUIPPED TO SOLVE THESE PROBLEMS?

As prime contractor for IRBM and ICBM Nose Cone Development, MOSD can draw on a reservoir of top level experience and skill. This G-E department also has a backlog of significant experience in the development and manufacture of Naval Fire Control Equipment, such as range-finders, computers and radar antennas.

NEW OPPORTUNITIES FOR ENGINEERS WITH EXPERIENCE IN THE DEVELOPMENT OF GUIDANCE & FIRE CONTROL SYSTEMS

A new group is now being formed to work on Polaris Missile Sub-Systems at MOSD. It will be located at Pittsfield, Mass. in the heart of the Berkshire resort and vacation area. Openings are at all levels for men with experience in:

GUIDANCE & ELECTRO-MECHANICAL COMPONENTS

Design, evaluation of guidance and fire control equipment

Design, development of electro-mechanical components and servomechanisms

Design, development, evaluation of inertial components, synchros, pick-offs, accelerometers, stable platforms, platform gimbals, verticals, etc.

Design, development, fabrication of analog computers for guidance and fire control systems

GUIDANCE & CONTROL SYSTEMS

Mathematical analysis, feasibility study of control systems and techniques

Synthesis, design, evaluation of guidance and fire control systems

Laboratory development, testing, modification of control systems

ELECTRICAL & ELECTRONIC COMPONENTS

Development of amplifiers and associated circuitry

Development, packing of electronic, magnetic, transistor servo type circuits and components

Reliability, evaluation, analysis of electronic circuits and components

Design, development of fire control consoles

Systems integration, design of electrical and electronic components

Development of electronic and solid state devices, semi-conductors, new transistor applications

OPPORTUNITIES OPEN ON OTHER MISSILE PROGRAMS

Engineers and Scientists with experience in other areas of Electrical Engineering, Aeronautical Engineering. Aerodynamics, Mechanical Engineering, Physics or Mathematics should inquire about positions on other missile programs at Missile and Ordnance Systems Department.

AN INVITATION

If you would like to contribute to any of the advanced missile development programs at MOSD, you are invited to send a resume of your education and experience. Or write us for a convenient application form. All resumes will be carefully reviewed by the MANAGERS *of our various technical components. You will be invited to visit our offices and discuss work we are doing directly with the Manager with whom you will be working. Communications will be entirely confidential.*

Please send resume to Mr. John Watt, Room 595-5

MOSD

MISSILE & ORDNANCE SYSTEMS DEPARTMENT

GENERAL ELECTRIC

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Curtiss-Wright Profit Up for 1st Quarter

Curtiss-Wright Corp. reports a consolidated net profit of $9,942,256 for the first quarter of 1957. More than 60% of these earnings stem from commercial business, it was noted by Roy T. Hurley, president and chairman.

Consolidated net sales for the same period were $147,427,760. Unfilled orders plus scheduled production under advanced contracts amounted to $147,427,760. A year ago, figures showed profits of $9,196,100 on sales of $132,641,353. Commercial business accounted for half the earnings in 1956.

NAA's Neosho Plant Producing *Thor* Engines

North American Aviation, Inc., has begun production of rocket engines at its Neosho, Mo., Rocketdyne plant following the receipt of an Air Force contract for a number of *Thor* IRBM propulsion systems.

Engines for *Thor* are in the developmental production at Rocketdyne's main plant at Canoga Park, Calif. Production at the Neosho plant will employ more than 1,500 persons by June 1958. About 650 of Rocketdyne's 10,000 workers are now at the Missouri facility.

Rocketdyne also is developing high thrust rocket engines for the *Jupiter*.

GE Adds Vermont Plant To Missile Systems

General Electric Co. recently has added guided missile production facilities to the Missile and Ordnance Systems Department.

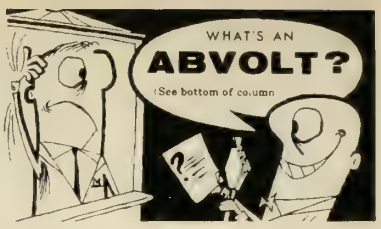
According to MOSD General Manager George F. Metcalf, the production capability was added to supplement existing research and development capacities. The department has acquired existing GE facilities at Burlington, Vt., consisting of 400,000 sq. ft. and 1,600 trained employes.

Chief production items will include missile nose cones and arming and fuzing systems.

WDD Name Changed

Western Development Division of Air Research and Development Command has been renamed "Headquarters, ARDC, Ballistic Missile Division."

No changes in mission or organization were involved. The name change



was made to provide a more descriptive title in keeping with the expanded scope of Air Force responsibility in the ballistic missile field.

GE to Design *Polaris* Fire-Control System

General Electric's Missile and Ordnance Systems Department has been awarded a Navy contract for $1,500,000 to design and develop a fire-control system for *Polaris* mid-range missile.

Missile, which may be launched from surface ships or submarines, is built by Lockheed Aircraft Corp. Engines are solid-propellant rockets built by Aerojet-General Corp.

Convair-Astronautics Receives Work Assist

Convair-Pomona will give an assist of 50,000 hours of direct labor to Convair-Astronautics under terms of an inter-division work transfer agreement approved by the Air Force and Navy Bureau of Ordnance.

Pomona has nearly completed an earlier 75,000-hour engineering assist program begun last year for Astronautics Division.

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Fast Tax Writeoffs Granted Missile Firms

Douglas Aircraft Co., Sacramento, has been granted a certificate of necessity for accelerated tax amortization for a missile test facility in the amount of $2,455,600 at 70% by the Office of Defense Mobilization.

Other fast writeoffs for the missile industry include:

Tele-Dynamics, Inc., Philadelphia, telemetering systems for guided missiles, $203,575 at 70%.

Lockheed Aircraft Corp., Sunnyvale, Calif., research and development, $927,188 at 60%.

Lockheed Aircraft Corp., Sunnyvale, Van Nuys, and Palo Alto, Calif., research and development, $713,049 at 65%.

The Martin Co., Jefferson County, Colo., missiles, $110,000 at 60%.

Aerojet-General Corp., Sacramento, research and development, $945,000 at 60%.

The Martin Co., Denver, guided missiles, $108,296 at 65%.

Kansas Plant to Produce Boron Chemicals

Callery Chemical Co. has begun construction of a $3 to $4 million plant at Lawrence, Kan., for production of boron specialty chemicals for commercial use.

The facility is slated to begin production early next year and will employ 150 persons. It will consist of 11 buildings and four chemical processing areas. The plant is slated for a 200-acre site two miles north of Lawrence.

Callery is owned jointly by Mine Safety Appliances Co. and Gulf Oil Corporation.

Litton to Build Factory At Salt Lake City

Litton Industries is planning a 60,000-sq. ft. plant at Salt Lake City for manufacture of magnetrons, klystrons and other microwave tubes. The plant, Litton's 11th, is expected to employ about 600 people. No completion date has been announced.

Olin-Mathieson Sales Up, Earnings Down

Olin-Mathieson Chemical Corp. reports first quarter sales of $135,479,249 and net income of $10,009,979 compared to $144,340,677 and $10,080,099 last year. Earnings per share amounted to 75¢ compared to 76¢ at the same time in 1956.

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Coordinate project analysis, planning and controls including determination of project requirements and commitments in missile field.

ELECTRONIC SYSTEMS ENGINEER (Field Service)
Liaison with associate contractors and government agencies on inertial guidance system project. Must be thoroughly familiar with matters relating to digital and analog computers, power supplies, environmental conditions, housing and test facilities and test equipment.

FIELD EVALUATION ENGINEER
Perform overall planning functions for field evaluation of missile guidance systems. Direct activities in scheduling the field operations. Liaison with field test site agencies and formulating overall operating procedures at test site on missile project.

MECHANICAL DESIGN ENGINEER
Perform mechanical design of airborne instrumentation and transducers required for field evaluation of missile guidance systems. Responsible for packaging and mounting equipments.

FUNCTIONAL ENGINEERS — MISSILE SYSTEMS
Develop inertial guidance systems including gyro, accelerometers, integrators, servo systems and computers. Analyze functional problems arising during development and evaluation of said system.

OPERATIONAL EVALUATION ENGINEER
Perform engineering studies and analysis of techniques for evaluating performance of missile guidance systems and its components including gyros, accelerometers, digital computers.

PLATFORM ENGINEER
Conduct investigation of a theoretical nature relating to gyros or inertial platforms including design of closed loop control equipment pertaining to the above.

GYRO DEVELOPMENT ENGINEER
Develop precision gyro systems including mechanical problems such as lubrication, temperature controls, hydrostatics and vibration and electronic work on accelerometers, amplifiers, torquing circuits and electrical pickups.

OPERATIONAL ANALYSIS ENGINEER
Development work on evaluation of inertial guidance systems including in-plant and flight analysis of gyro systems. Development of measuring devices for precise determination of in-flight velocity, acceleration, altitude and position information.

RELIABILITY ENGINEER
Develop methods for evaluation of accuracy, reliability and operational suitability of missile guidance systems.

SYSTEMS EVALUATION (MISSILE GUIDANCE)
Perform functional engineering studies and design of inertial guidance systems, determine system and component requirements and performance, conduct system and component dynamic studies and simulation, perform error analysis.

PROJECT ENGINEER — PRODUCTION TEST EQUIPMENT
Administer and technically direct the program of design, development and manufacture of test equipment for production use in the manufacture, inspection, test and reliability control of highly complex electronic, electro-mechanical and gyroscopic equipment required for missile application.

GROUND EQUIPMENT ENGINEER
High degree of technical and administrative responsibility on complex projects involving the design and development of production test and field test equipment for gyroscopic systems and digital computers.

PROJECT ENGINEER — AIRBORNE EQUIPMENT
Guide and assist engineers in technical problems in field of electrical and electronic design, servo systems, missile guidance systems. Responsible for major product improvement program and test programs. Provide technical liaison with quality control. Heavy servo background desired.

ENVIRONMENTAL ENGINEER
To plan, conduct and report upon development studies of finishes, materials and processes, which will be incorporated into the design of electromechanical and electronic components and systems.

OPERATIONAL ANALYSIS ENGINEER
To plan, conduct and report upon environmental tests of electromechanical and electronic systems. Must be capable of redesigning components or systems to correct any deficiencies encountered during the evaluation program in the computer, servo systems and missile field.

QUALITY CONTROL ENGINEER
Require experience in gyroscopic trouble shooting. Design knowledge of stable elements and some background regarding reliability and failure association for complex guidance systems to be used in missile field. Must have complete knowledge of statistical methods.

GROUND EQUIPMENT ENGINEER
Plans and performs engineering studies, basic electrical and mechanical design, development and evaluation of production test and field test equipment where specific objectives and general requirements are known. Must be familiar with electromechanical instrumentation.



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B.S. in M.E., A.E. or equivalent with a minimum of 5 years airframe powerplant experience. Your background should also include engineering and customer contact on technical products and services. You will assume responsibility for organizing a program to apply new and existing powerplants to all types of missiles. 2-3 days of your week will be spent answering inquiries and preparing proposals, the remaining 2-3 days traveling.

SENIOR DESIGN ENGINEER

Prefer M.E. or A.E. degree and a minimum of 6 years experience in aircraft engines or airframes. You should have extensive design experience, including plenty of board time, shop contact, structural design, stress analysis. You will be working directly with design engineers and layout draftsmen on design of light weight, complex structures.

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Radioplane to Become Division of Northrop

Radioplane Co. will become a division of Northrop Aircraft, Inc. later this year and the current subsidiary status will be dissolved. The name Radioplane will be retained.

Under divisional status, the vice president and general manager of Radioplane will have operational responsibility and authority. Whitley C. Collins, president of Northrop is also president of Radioplane.

Radioplane recently received a $6,631,765 contract for target drones and radio receiver selectors.

NAA Separates Missile Administration

North American Aviation, Inc., is separating manufacturing administration of its Missile Development Division from its Los Angeles Division in a series of steps to be completed by July 1.

The MDD organization will be headed by J. Y. Cunningham, general superintendent. Missile work at Los Angeles has consisted of tooling and sheet metal parts, machined parts, welding, assembly of large structural components on both SM-64 *Navaho* missile and booster.

R & D Costs at Temco Curtail Earnings

Temco Aircraft Corp. had sales of $27,226,605 for the first quarter of 1957 resulting in net earnings of $294,798. A year ago the figures were $19,621,602 and $644,847.

President Robert McCulloch said that the drop in earnings was because of costly research and development projects from which financial results have not yet been felt.

Among Temco development programs are the XKDT-1 rocket-powered missile target drone and the Navy *Corvus* missile.

Rocketdyne Engines Power Test Sleds

Liquid propellant rocket engines built by Rocketdyne division of North American Aviation, Inc., have accelerated 5,000-lb. test sleds to 900 mph in 4.2 sec.

The engines have been in use at Edwards and Holloman Air Force Bases for more than four years in connection with missile and aircraft development programs. They produce between 35,000 and 50,000 lbs. of thrust.

The Rocketdyne engine reaches 80% of full thrust in 1/10 sec. accel-

erating at 10 g's. One of the engines has been fired more than 120 times.

Rocketdyne describes the engines as nitrogen pressurized systems using propellant mixtures of alcohol and liquid oxygen. The propellants, pressurized at 3,000 psi, are introduced by high speed valves into the thrust chamber through an injector plate. Multiple holes in the plate, drilled at various angles, effectively mix fuel and oxidizer for the most efficient combustion combination. Mixture burns at about 4,700°F at full thrust.

The sled engine principle of operation is basically the same as larger liquid propulsion systems manufactured for long-range missile use.

Rocketdyne Sets Up Service Division

North American Aviation's Rocketdyne Division has set up a service division to speed up and simplify maintenance and supply for ballistic missiles.

Manager of the unit is J. A. Broadstone, former manager of Rocketdyne's propulsion field laboratory. Rocketdyne responsibility will include maintaining inventory of all parts through a warehouse system, operation of an overhaul and modification center, and the manufacture of spare and modified parts.

Army Seeks Money To Overhaul *Nikes*

Army has asked for funds to rebuild some 4,000 *Nike* missiles in fiscal 1958, according to House Appropriation Subcommittee testimony.

Corrosion and deterioration of parts from exposure and repeated testings were cited as reasons for the rebuilding. Some of the *Nikes*, Army revealed, have been in launchers for 20 months.

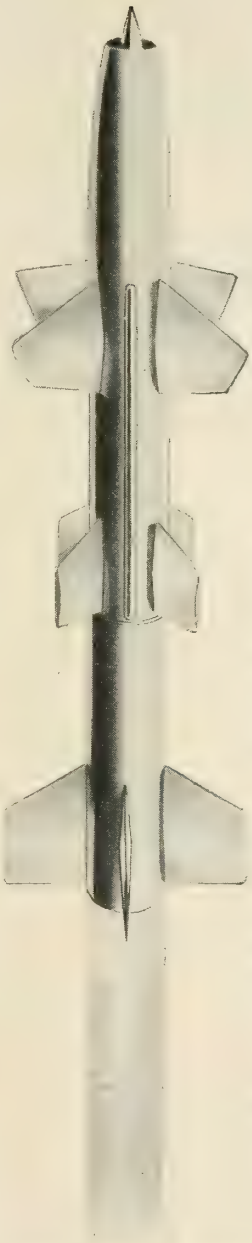
No costs have been mentioned.

Garrett Sales Up 33.5%

The Garrett Corp. reports a net profit of $3,563,651 from consolidated sales of $131,468,678 for the nine months ending March 31. Sales figures represent an increase of 33.5% over the same period last year. Current backlog is reported at $155 million, $50 million more than at same time in 1956.

Olin Mathieson Sales Down

Olin Mathieson Chemical Corp. reports first quarter sales in the U.S. and Canada of $135,479,249 and net income of $10,009,979. Year ago sales were $144,340,677, earnings were $10,080,099.



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Boeing Vibrator Mount Aids *Bomarc* Testing

A vibrator mount which eliminates unwanted outside vibrations is being used at the Pilotless Aircraft Division of Boeing Airplane Co. in the testing of instruments used in the *Bomarc*.

The Boeing-developed tool consists of a 5,000-lb. concrete triangle which is suspended on six oppositely-wound coil springs inside a steel frame.

The vibrator is suspended in a large cup inside the triangle. The depressed housing of the vibrator places it at a point which is both the center of suspension and center of gravity. As a result, when the vibrator is pivoted to any degree between horizontal and vertical, gravity will not create a conflicting force upon the direction of the vibration.

The equipment is called a "Seismic Mount for a Vibration Calibrator." It virtually eliminates unwanted vibrations except those near and below 1½ cycles per second.

Vibrations varying from 2 to 2,000 cycles per second and attaining a force of 20 g's can be generated.

Converter Translates Computer Data

A bilingual electronic computer that "speaks" in both analog and digital terms is making faster, more flexible and more accurate calculations in Convair's *Atlas* ICBM performance study.

Analog and digital computers, essential tools of aircraft and missile designing, do not "speak" the same language. Analog systems, for example, express quantity by measurable physical characteristics such as voltage, rotation and resistance. Digital systems express quantity in exact numbers.

Analog computers are fast, but lack accuracy and flexibility. Digital computers are highly accurate and flexible but often are not fast enough.

Convair-Astronautics and Epsco, Inc., have succeeded in mating the two computing systems on a large scale. A $200,000 computer-converter called Addaverter converts problem data from analog to digital and digital to analog, thereby uniting the best features and decreasing the disadvantages.

To bridge the equipment with the Addaverter requires 7,700 lbs. of electronic materials housed in cabinets eight ft. high, 15 ft. long and two ft. deep. The Addaverter contains 2,000

vacuum tubes and about 4,500 germanium diodes. Its display panel contains nearly 600 flashing lights. It uses 15,000 watts.

Terrier Missiles Get Radar System

U. S. Navy's *Terrier* missiles are guided by long-range radar capable of scanning airspace many miles beyond the horizon, according to Sperry Gyroscope Co. which makes radar system.

The SPQ-5 radar can select individual targets from close-flying groups and track them for missile guidance and interception.

Now installed on the missile cruiser Canberra, the radar antennas resemble giant searchlights. The USS Boston is also *Terrier*-equipped and three other ships are being fitted—the *Topeka, Providence* and *Springfield.*

Sperry Piedmont Co., a Sperry facility, is producing the radar at Charlotteville, Va.

Elgin Watch to Build R & D Plant Near LA

Micronics Division of Elgin National Watch Co. will construct a research and development plant in the Los Angeles area to handle expanding west coast operations.

The 20,000-sq. ft. building will be at Canoga Park and occupancy is expected by September 1. Micronics is engaged in the development of high-precision missile and aircraft parts.

Aerojet Workers Get 7 Cent Wage Hike

Aerojet-General Corp. hourly employes received a 7¢ per hour wage increase effective May 13 in accordance with a two-year agreement negotiated a year ago with the International Association of Machinists.

At the same time the company announced a 3% general increase for salaried employes, effective May 16. The company had about 6,500 hourly and 3,300 salaried employes.

Hoffman Sales Increasing

Hoffman Electronics Corp. realized a first quarter net profit of $512,802 on sales of $11,493,599, compared to net of $467,994 and sales of $12,155,-019 in same period last year. Company predicts 1957 sales and earnings 10% above 1956.

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Ford Instrument Company's new Missile Development Division is expanding because of increased activity on guidance and control work for major ballistic missiles such as the Redstone and Jupiter.

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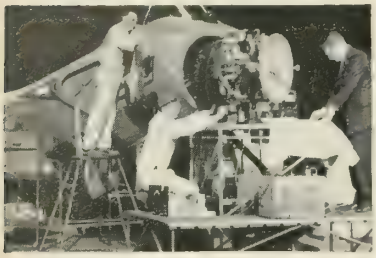
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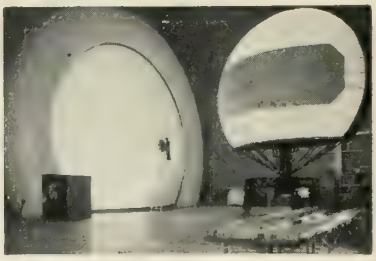
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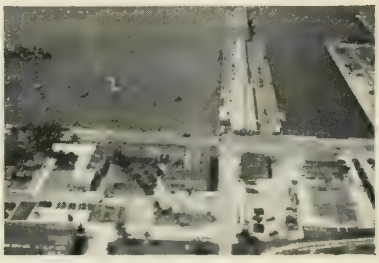
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German Rocket Growth Slow But Sure

There is little rocket industry as yet in Germany but from numerous points there are indications that development is underway. One such organization, Bölkow Luftfahrtenwicklungen KG (Bölkow Aero Developments) have a Sam or anti-tank rocket in advanced stages of development. Bölkow, 42, of Stuttgart, is well acquainted with U.S. developments. Another organization becoming active is the Raketenfertigungs-GmbH (Rocket Assembling, Inc.) of Giessen.

From Munich it is learned that Mr. Richard Stangler, head of German Association of Aircraft Standard Parts Industry, Frankfurt, has formed a Verband der Raketenindustrie (Association of the Rocket Industry).

Ingots Produced From Compacted Sponge

Oregon Metallurgical Corp. is producing titanium and zirconium ingots and billets from compacted sponge, utilizing the technique of consumable electrode, arc melting under vacuum or inert gas in a water-cooled copper crucible.

Ingots are available as pure titanium, zirconium, or alloyed with chromium, manganese, tantalum, columbium, platinum or other alloy combinations.

North American Gets Options on Nevada Site

North American Aviation, Inc., has obtained options to purchase some 12,600 acres in Washoe County, Nev. The property is located 10 miles northeast of Reno.

The location is being considered among others for future development of manufacturing and test facilities, possibly in electromechanical and rocket fields, according to J. S. Smithson, vice president—administration.

Marquardt Sales Up

Marquardt Aircraft Co. reports sales of a 16-week period ending April 27 were $11 million, up 110% over the comparable period a year ago. Net profit for the period was $235,000.

Stockholders have approved an increase in company's stock from 300,000 to 1 million shares.

Aerojet gets JATO Order

Aerojet-General Corp. has received a $3.5 million contract from Navy Bureau of Ordnance for manufacture of JATO units and spare igniters. The solid-propellant perchlorate oxidizer units will be made at Sacramento.

Ryan Gets $4 Million For More *Firebees*

Ryan Aeronautical Co. has received a contract in excess of $4 million for a quantity of KDA-1 *Firebee* jet target drones for the Navy. The new order closely follows other *Firebee* contracts totaling $15,500,000 from the Air Force and Navy.

Orders for the drone missiles will require expanded production schedules well into 1958, according to president T. Claude Ryan.

Republic Quarter Sales Top $76 Million

Republic Aviation Corp. consolidated sales for the first quarter amounted to $76,645,222 and net income stood at $1,776,738 or $1.21 a share. This compares with figures of $81,798,731 sales and $2,129,663 or $1.45 a share earnings in the first quarter of 1956.

Republic's backlog March 31 was $177 million and contracts being negotiated at that time were valued at an additional $371 million.

ARDC Opens Office In San Francisco Area

Air Research and Development Command has opened a new development field office in the San Francisco Bay area to provide a close link with private research institutions and industries in the region.

The office is temporarily located at Moffett Field but the permanent location will be in or near Palo Alto. In charge is Capt. Otis R. Hill, formerly of ARDC headquarters, Baltimore.

Siegler Gets Contracts For *Atlas, Titan* Gear

The Siegler Corp.'s Hallamore Electronics Division has received a contract of more than $9 million for engineering and production of a high-priority guided missile program.

The contract reportedly is for electronic test and check-out equipment for the Martin *Titan*. Earlier Siegler received a $4 million contract for similar test and check-out gear for Convair's *Atlas*.

AN FITTINGS

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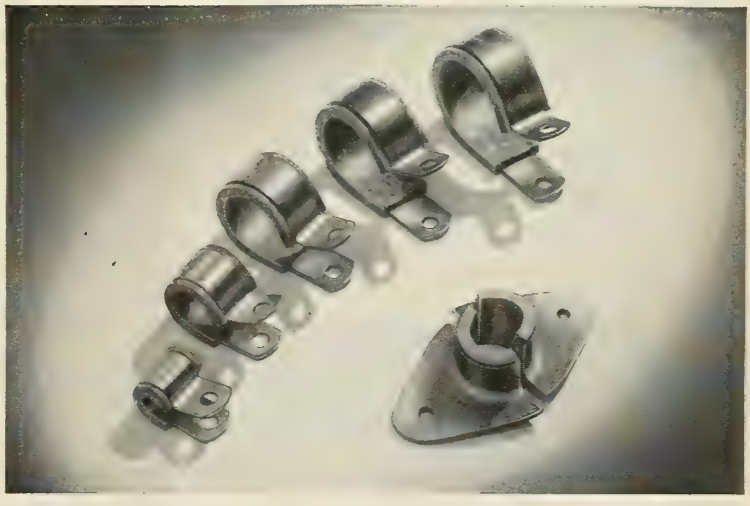
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Speakers at Southern Research Institute's recent Space Flight Symposium included: Erik Bergaust, Exec. Ed., m/r; Dr. Ernst Stuhlinger, ABMA; Dan A. Kimball, pres., Aerojet-General; F. L. LaQue, v.p., International Nickel Co.; Gen. D. C. Ogle, AF Surgeon General; Dr. J. P. Hagen, Project Vanguard Chief; Dr. C. C. Furnas, former Assistant Defense Secretary.



KERR

James R. Kerr has been appointed president of Lycoming Div., Avco Mfg. Corp. His current assignment is head of Avco's Office of Defense Planning.

Joseph F. Caslin has joined the Associated Missile Products Corporation as staff assistant to the gen. mgr. Prior to this appointment he was head of the guided missile ground support equipment div. of the Turbo Div., American Machine and Foundry Co.

Dr. J. Victor Hughes has joined the scientific research staff of Republic Aviation Corp. as an associate scientist. He was director of the general physics laboratory of Continental Can Co.

Kenneth B. Boothe has been named director of sales for Kahn Research Laboratories.

Robert N. Himmel and **R. Kenneth Davis** will staff the new Semiconductor-Components division marketing office of Texas Instruments at Camden, N.J.

Gene Lowe has been appointed vice president—manufacturing at the Benson-Lehner Corp.

Leroy W. Collins, formerly with International Latex Corp., has been appointed personnel mgr. of the Mechatrol Div. of Servomechanisms, Inc.

Harold W. Gear of Magnavox Corp. has joined the Chemistry Div. of the Atlantic Research Corp., Alexandria, Va., as processing supervisor of solid propellant rocket fuel charges. **Howard H. Niederman** has joined the Western Div. of Atlantic Research as consultant in solid propellant rocketry and chemical engineering.

Samuel M. Kinney, Jr., has been elected secretary of Daystrom, Inc., Roy Sandquist has been elected treasurer, and Robert R. Whelan, asst. secretary.

Col. John P. Gibbons of the Air Materiel Command will be the Air Force plant representative for The Martin Co.'s Guided Missiles Division at Denver.

J. Russell Clark has been promoted from asst. chief engineer—aircraft projects to chief engineer—aircraft, and Samuel O. Perry from asst. chief engineer—missile projects to chief engineer—missiles at Chance Vought Aircraft, Inc.



TERRY

Philip D. Terry, formerly an aircraft field engineer with the Los Angeles Valve and Pump Co., has been named field engineer in charge of missile equipment and systems for Wm. R. Whittaker Co., Ltd.

Oscar T. Simpson has been named gen. mgr. of the new Western Development Laboratories of Philco Corp.'s Government and Industrial Div., at Redwood City, Calif. **Dr. Walter LaBerge** has been named mgr. of systems engineering. **Donold H. Clague** is business mgr.



MERRILL

Howard W. Merrill, director of operations at the Martin Baltimore Div., has been named a vice president of the company and gen. mgr. at Baltimore, succeeding **William B. Bergen** who remains executive vice president.

Robert L. Trent has joined Texas Instruments Inc. to direct a new engineering branch for applications and test equipment in the Semiconductor-Components Div. **R. J. Hanschen** has been appointed Mid-America region sales mgr. for the division.



Reaction Motors' Robertson Younquist, Tiokol's H. W. Ritchey and Douglas' R. B. Canright talk it over at recent French Lick, Ind., meeting of the Commercial Chemical Development Assn.

missile literature

ELECTRONIC EQUIPMENT RACKS. Illustrated 4-page brochure describes aluminum racks designed to accommodate standard RETMA panels of mobile electronic equipment. Craig Systems, Inc.
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SHAFT ANGLE CONVERTERS. Instrument which converts rotary motion into coded system of numbers described in 4-page brochure. Specifications, drawings, other data presented. Instrument Development Laboratories, Inc.
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TESTING FACILITIES. Environmental, metallurgical, chemical and quality control testing facilities outlined in 24-page brochure. Burgoyne Testing Laboratories, Inc.
Circle No. 102 on Subscriber Service Card.

METAL CASES. Stock sizes and shapes of instrument cases for special requirements of humidity, pressure, corrosion and MIL specs available to designers given in 62-page catalog. Zero Manufacturing Co.
Circle No. 103 on Subscriber Service Card.

BREATHING UNIT. Data sheet describes unit to protect workers during missile and rocket fuel handling operations. Scott Aviation Corp.
Circle No. 104 on Subscriber Service Card.

MISSILE FACILITIES. Capabilities and facilities of Rocket and Guided Missile Division to handle applied research and engineering, mass production of missiles and components described in 20-page brochure. National Electric Products Corp.
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STAINLESS STEEL DATA. Handy 32-page booklet has 20 tables including detailed data on stainless steel finder, corrosion resistance of various stainless steels, fabrication properties, weight tables. Allegheny Ludlum Steel Corp.
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BATTERY CONNECTORS. Information on battery connectors, power connectors and heavy duty connectors for many applications contained in 32-page catalog. Cannon Electric Co.
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HYDROFORMING. Complete service for forming prototypes and pre-production parts in missile and other industries outlined in 4-page pamphlet. C. B. Kaupp & Sons.
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TURBINE FLOW METER. Device for precise measurement of liquid flow is detailed in 8-page catalog, giving missile and aircraft applications. Fischer & Porter Co.
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TIME DELAY RELAYS, REPEAT CYCLE TIMERS. Two 2-page bulletins contains details on construction of three basic time delay relays in new extruded hermetic housings, and three basic miniature repeat cycle timers. A. W. Haydon Co.
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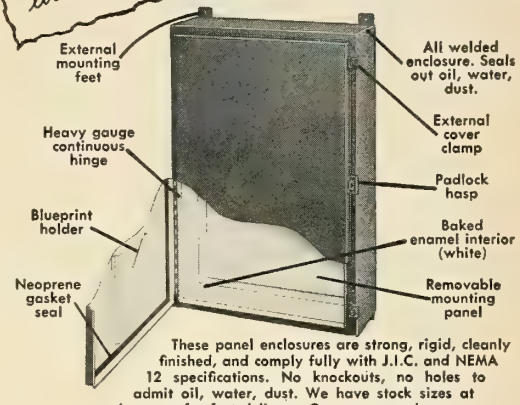
COUPLINGS, MISSILE APPLICATIONS. Complete line of hydraulic couplings, military test results, sizes, advantages covered in 4-page brochure. Second 4-page booklet lists missile uses, describes types used in launching, fueling, electrical checkout, rigid fuel lines, monofuel exhaust line. E. B. Wiggins Oil Tool Co., Inc.
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AUXILIARY POWER, COMPRESSOR, PNEUMATIC SYSTEMS. Two 12-page brochures outline operating and weight characteristics of compressors, pneumatic systems, auxiliary power systems for missiles or manned aircraft. Walter Kidde & Co., Inc.
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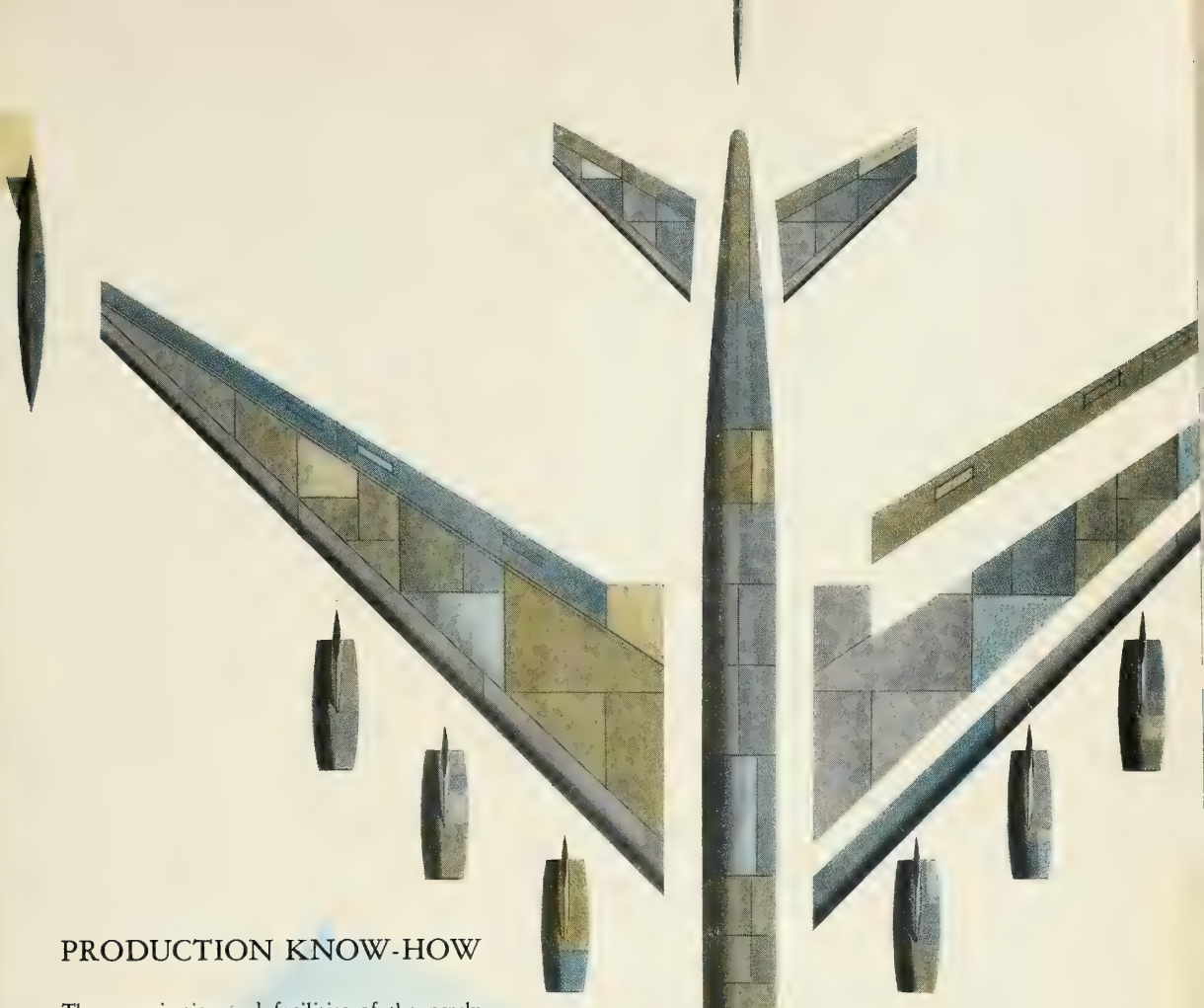
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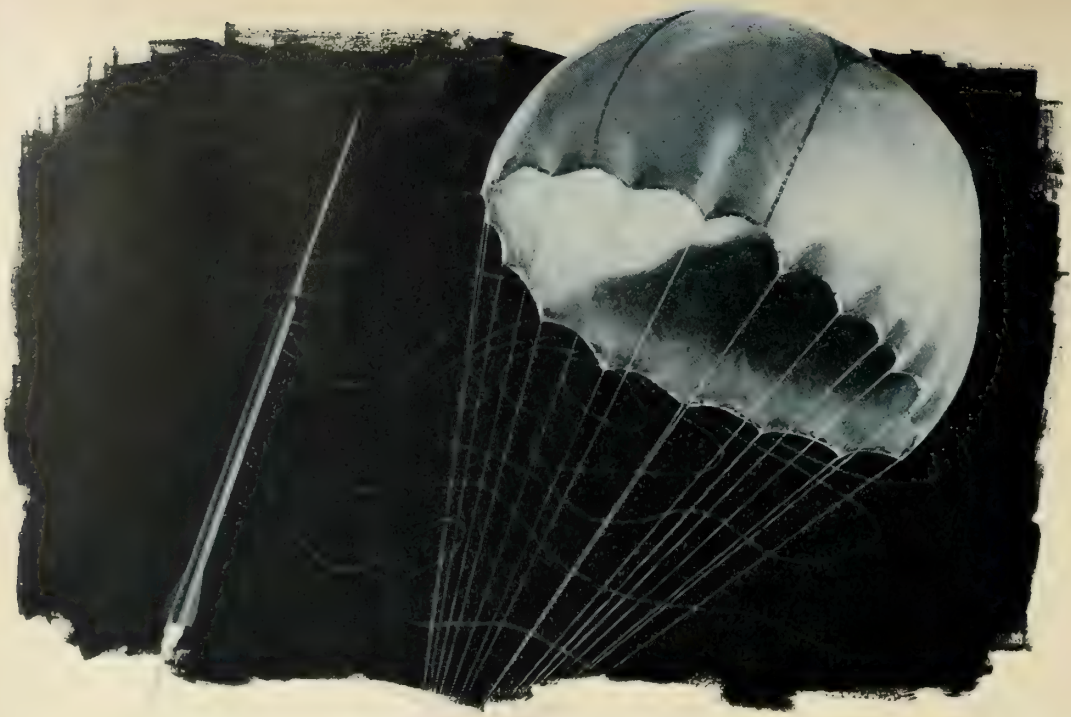
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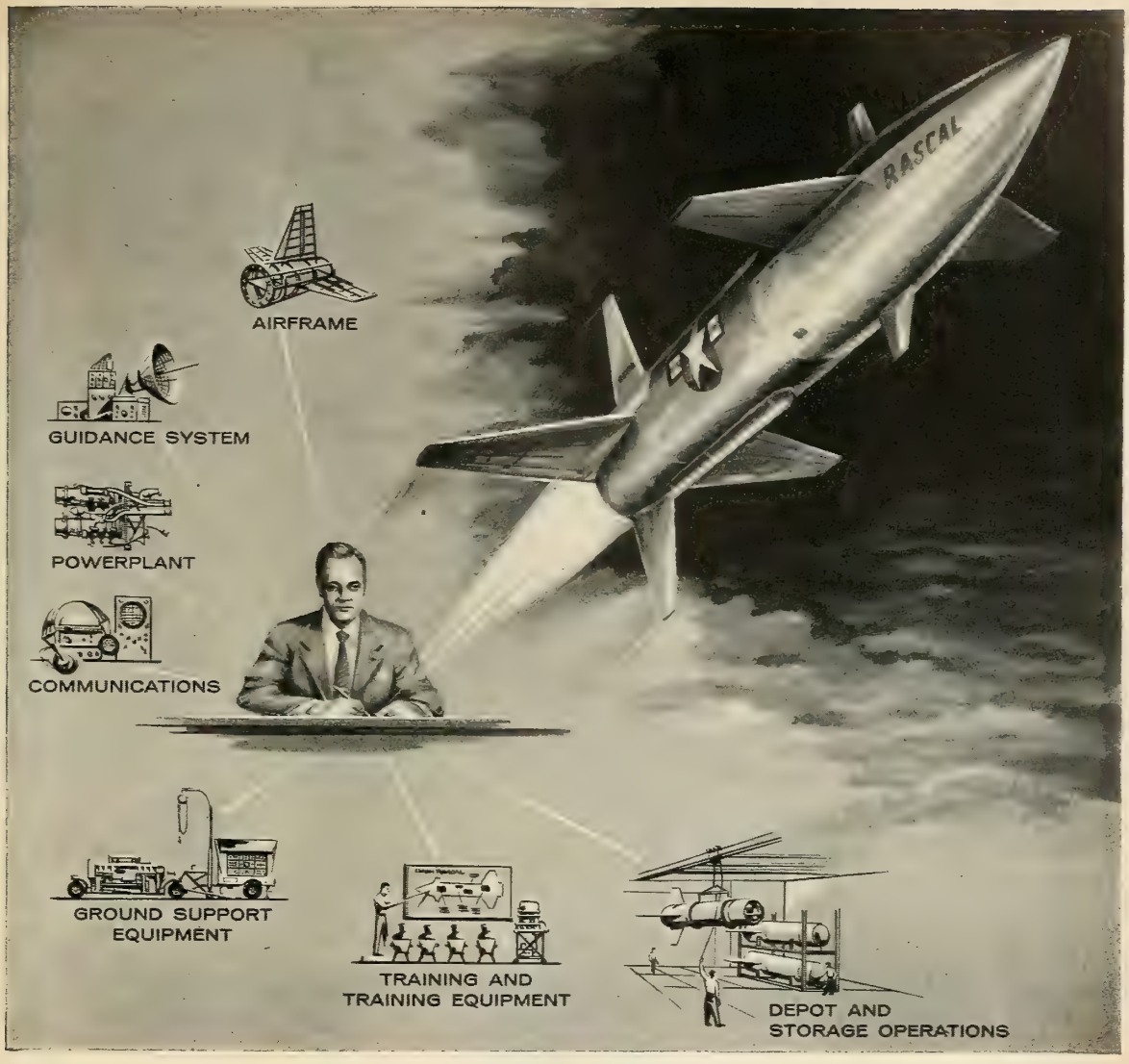
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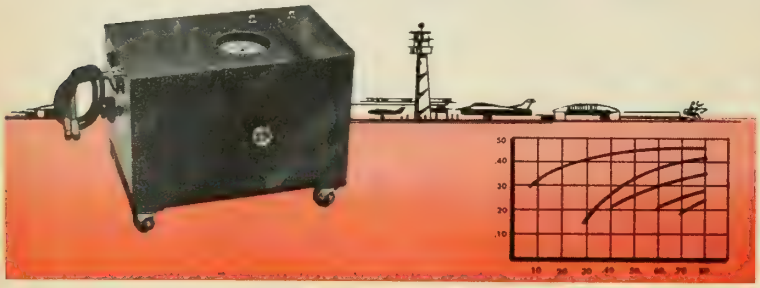
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The operating characteristics are interesting and one or both of these units may be able to do a specific job for you. Each unit is completely proven and has been skillfully designed for varied utilization, low cost, simplicity of operation and maintenance, and ease of transportation.

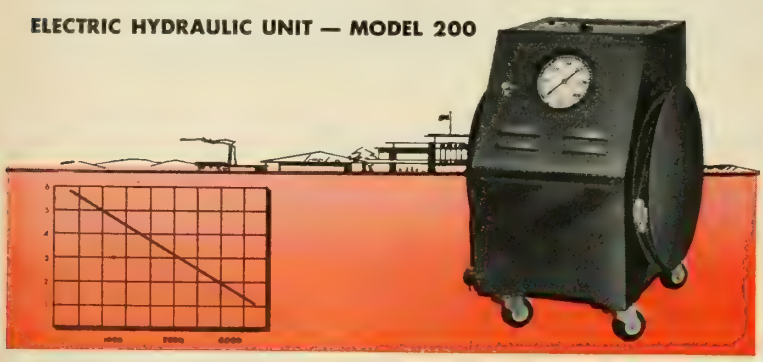
AIR HYDRAULIC UNIT — MODEL 100



This unit is explosion proof and features a demand system with constant pressure to 3000 psi. Pressure is accurately adjustable to 25 psi, the system is filtered and is powered by a piston-type, air-hydraulic booster pump incorporating an automatically operated air selector valve. All parts are commercially available.

SPECIFICATIONS:
Dimensions—19½" x 11¾" x 14" high.
Weight—75 pounds.
¼" pressure and return hoses, ⅜" air supply hose and 1 gallon reservoir.

ELECTRIC HYDRAULIC UNIT — MODEL 200



This 110V ac or dc unit features a demand system with constant pressure to 3000 psi. Pressure is accurately adjustable to 25 psi, the system is filtered and is powered by a high-speed, high efficiency gear pump. All parts are commercially available.

SPECIFICATIONS:
Dimensions—16¼" x 14¼" x 23" high.
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and ½ hp, 115V motor.

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July, 1957 Volume II, No. 7

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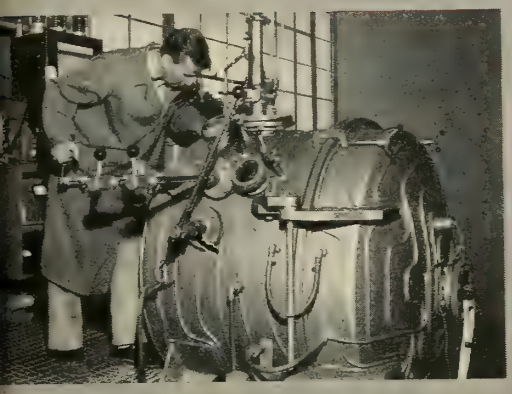
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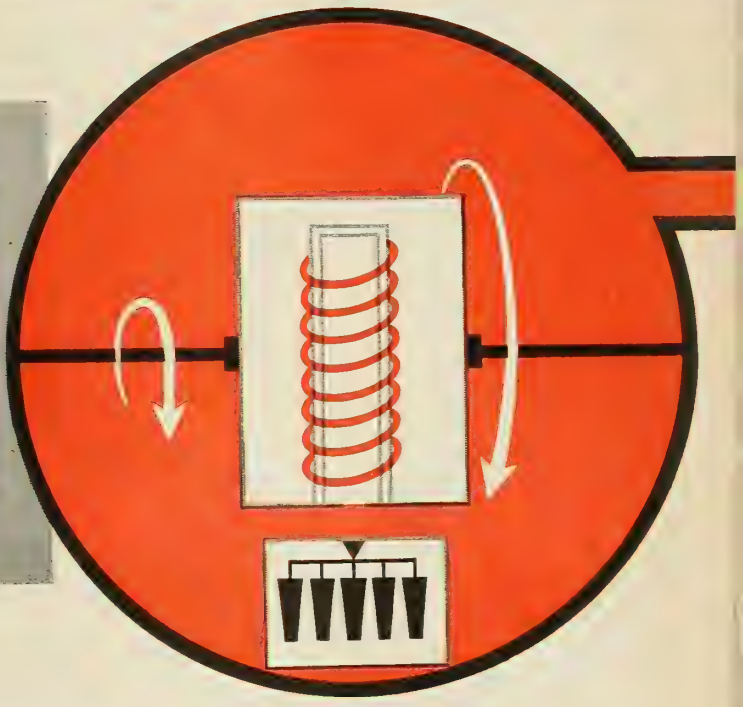
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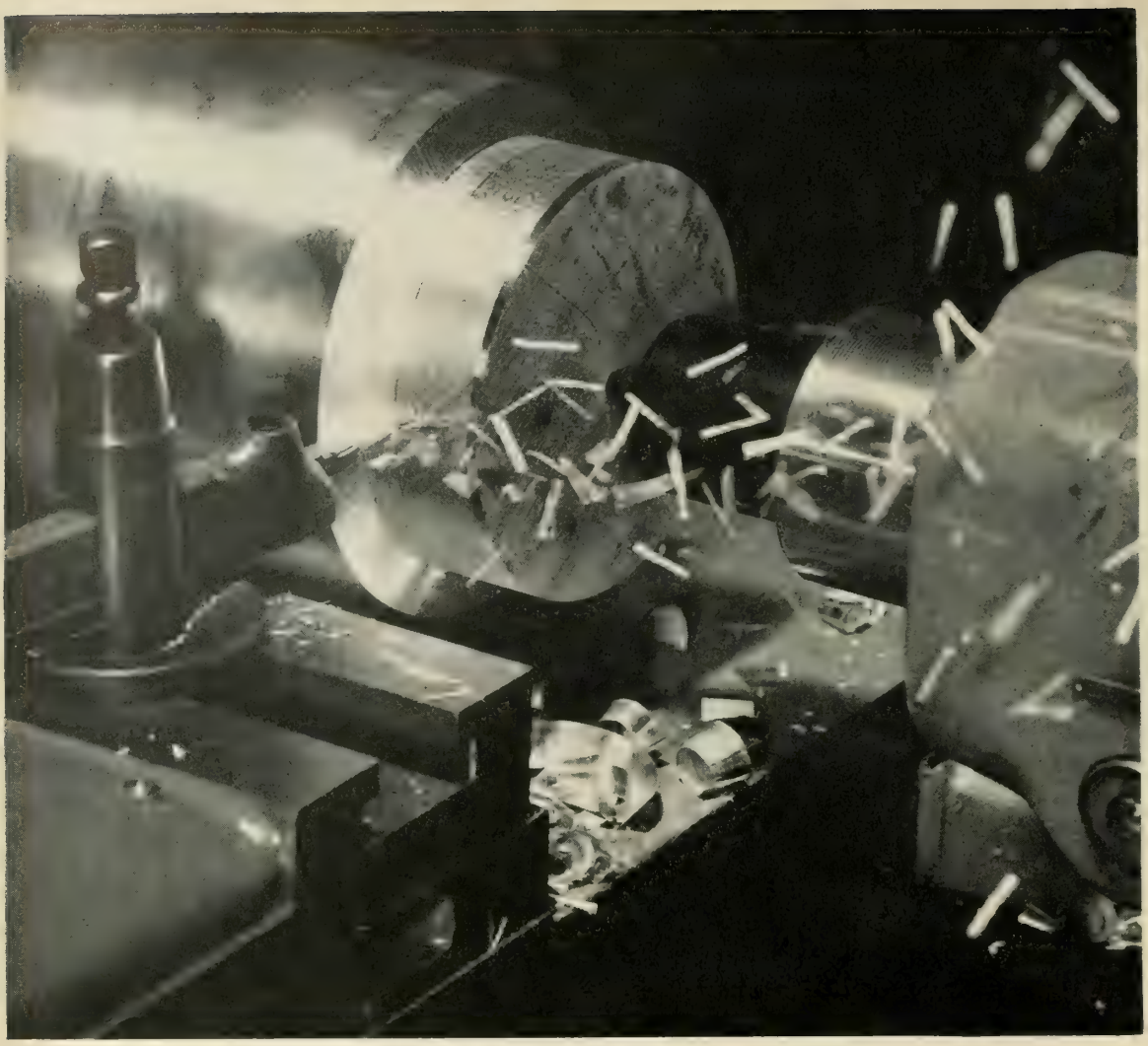
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guest editorial

Science and Common Sense



Radioactivity was discovered by Becquerel and explained by Lord Rutherford before 1900. In 1905, Albert Einstein postulated the equivalence of mass and energy according to the relationship $e=mc^2$. In 1945 a group of scientists crouched in Alamagordo's damp predawn to watch the world's first man-made nuclear blast sear the blackness. Nearly half a century elapsed from basic concept to weapon, although the same Albert Einstein advised President Roosevelt of the feasibility of an atomic bomb.

Today we would like the gap between idea and hardware be reckoned in months. The pace of development accelerates. To be sure, the scientist doesn't pull the trigger, or push the button, but he peers over the shoulder of the man who does.

We believe that the world is secure from nuclear self-annihilation only so long as the West maintains a weapons superiority that is obvious to the enemy. In general, this superiority is equidependent on: The discovery of new and better concepts; industry's ability to engineer and produce the hardware based on those concepts; and finally on men in authority recognizing the "next step" when they see it.

The need for people with a high degree of technical training is evident. Slowly, however, the problem of numbers is being solved. Missiles, rockets and space flight have fired the fancy of young America. More and more students in high school will tell you: "I want to be a missile engineer." Or, "I want to be aboard the first flight to the moon."

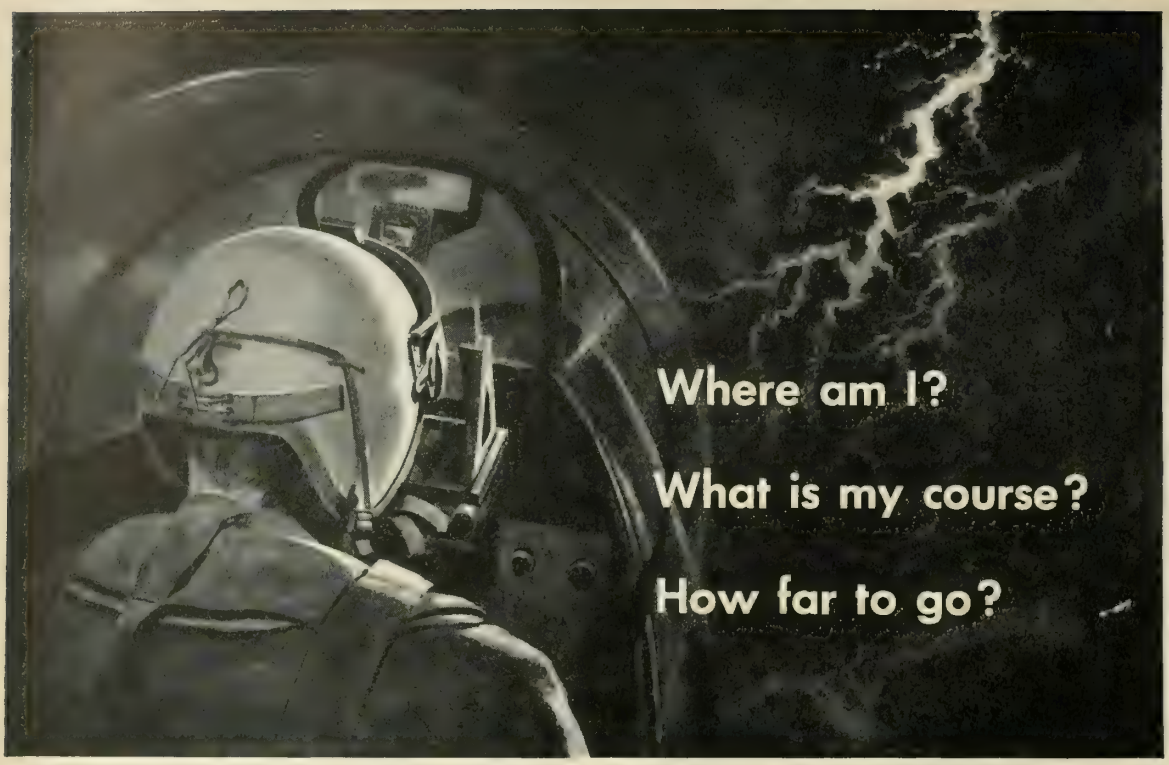
This is good. And for this purpose there is a primary need to lay more emphasis on the physical sciences as early as possible, especially in the upper high school grades. Fortunately this need is more and more recognized by educators and parent associations.

Also, the higher education at universities and colleges dealing with training of scientists and engineers must be broadened to avoid too narrow specialization. The modern history of aviation, especially the development of missiles and rockets, clearly shows that the engineer working in these fields needs education in more and more branches of the physical sciences. Aerodynamics became Aero-thermodynamics, then Aero-thermochemistry; for problems of guidance and command the aeronautical engineer must also be familiar with the broad field of electronics.

Essential is a constant awareness on the part of young people starting out that the world is complex and broadening—that all things in it are related.

This relates to a vital quality without which all the scientific ability imaginable would be to little avail. Instilling technological intuition—a working judgment of the physical sciences—into the business executive is tough enough. Even more difficult is the task of providing a broad base of *common sense* and evaluation for scientist and engineer whose whole educational and professional drive is high-lighted by specialization.

THEODORE VON KÁRMÁN.



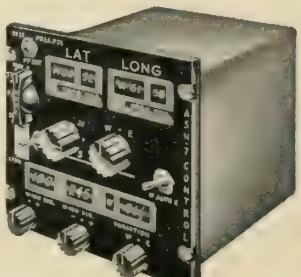
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Here Propulsion Staff members discuss problems relating to accurate positioning of a vehicle in the upper atmosphere. Left to right: J. F. Houle, propellant feed systems analysis; B. Ellis, Propulsion Department manager; J. J. Donhan, control force generators.

Lockheed

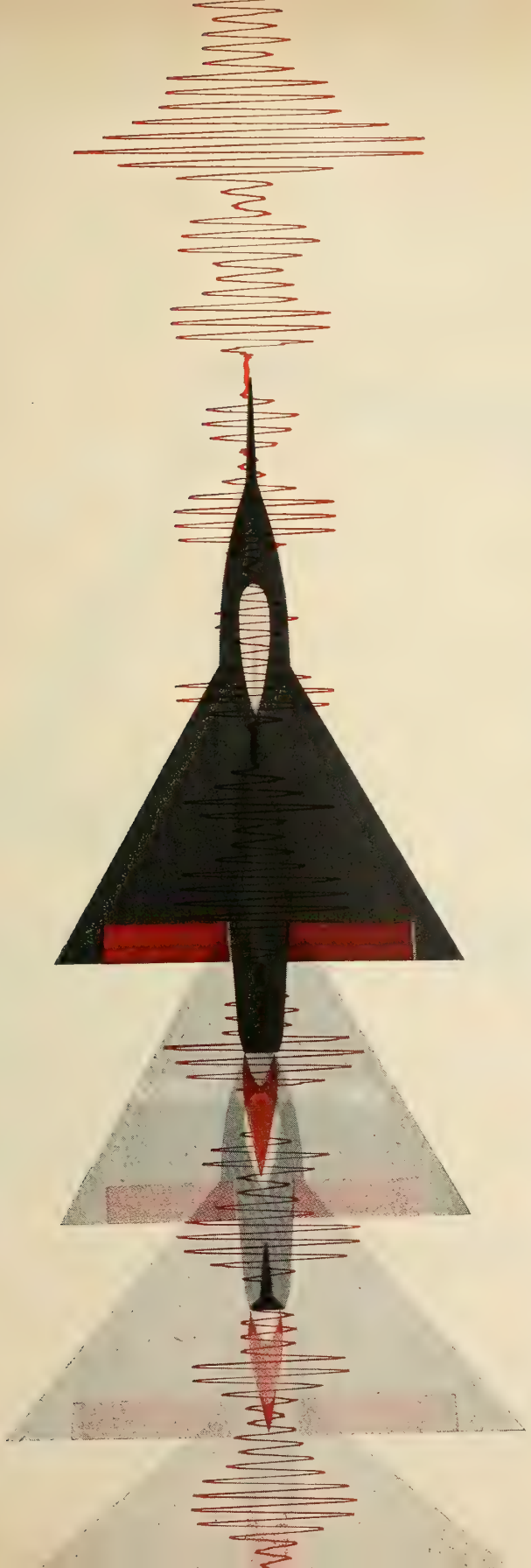
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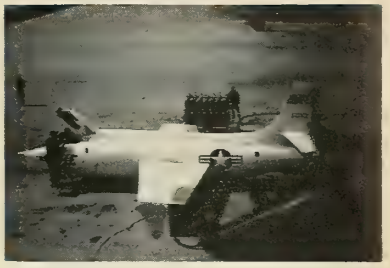
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PROGRESS IN HIGH-ENERGY SOLID PROPELLANTS

cover picture:



National Advisory Committee for Aeronautics has been instrumental in advancing manned rocket flight. For years NACA, in close cooperation with industry, has pushed research in this field. Obviously, this effort is undertaken with a complete understanding of the goal of manned flight—higher and faster, and finally toward the black yonder beyond our atmosphere. The cover picture, which was taken especially for m/r, shows our most recent rocket plane, the X-1E. See story on page 114.

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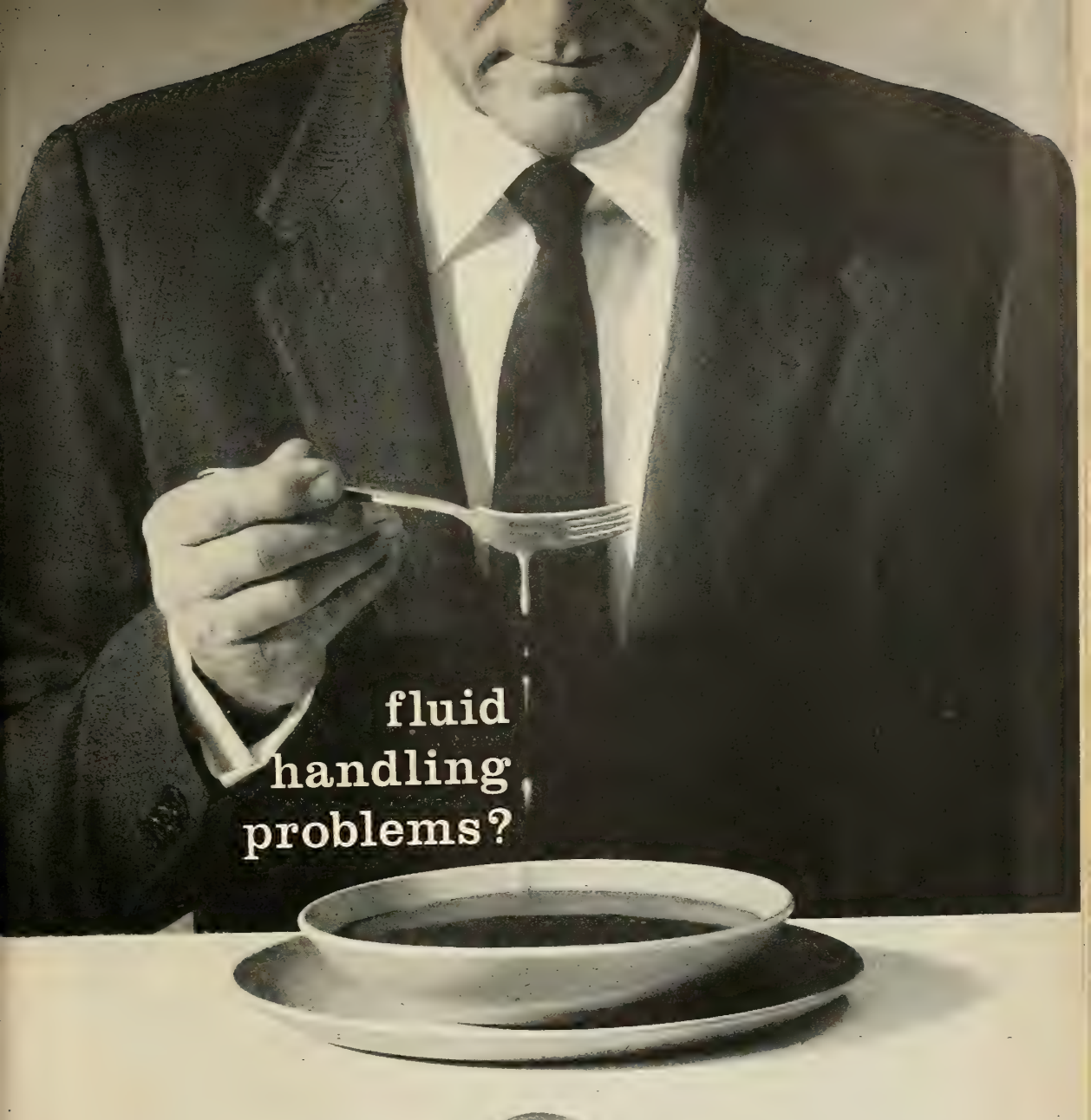
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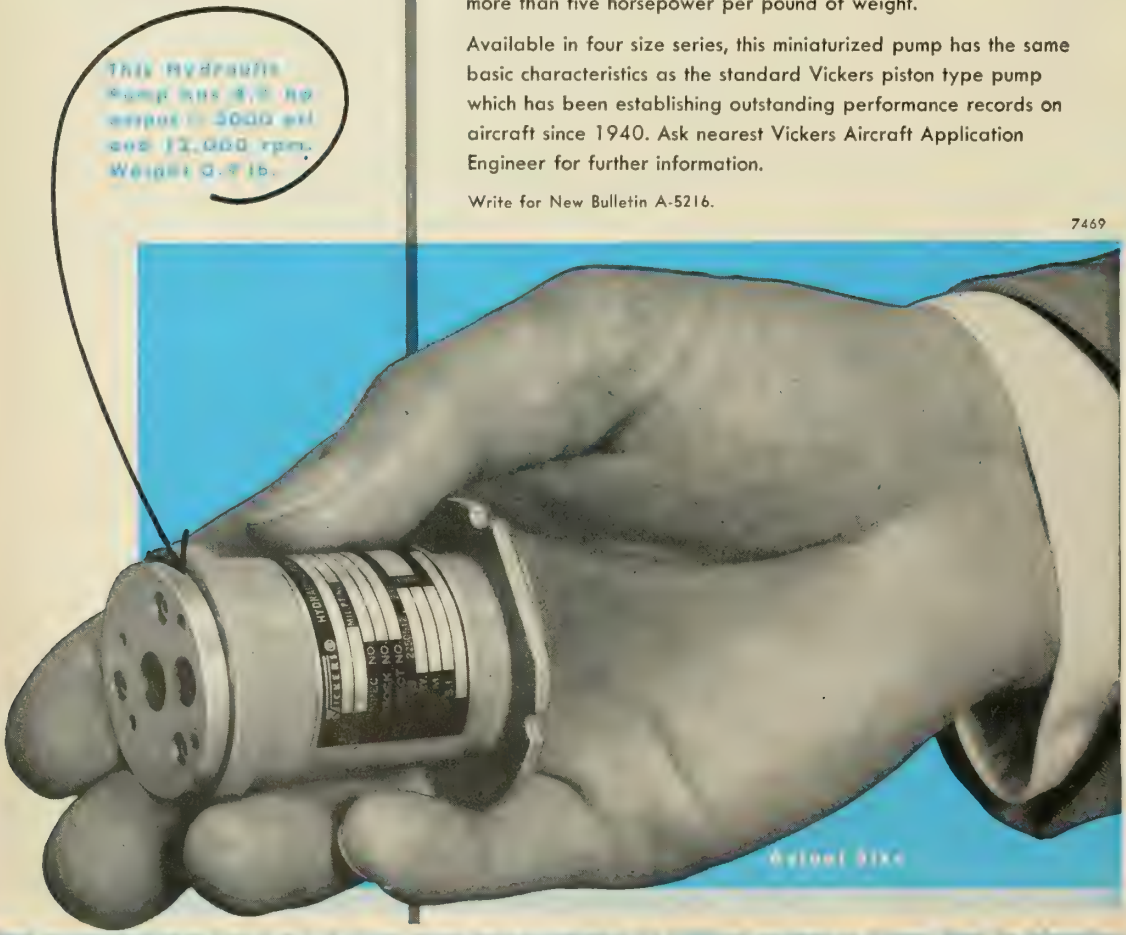
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A few positions for senior engineers and scientists are now open. Information on our accomplishments and goals is available in a new 30-page publication, just off the press.

In it staff leaders representing each of the various disciplines and fields outline the nature of their programs. Information on our new laboratory in Howard County, Md. (equidistant between Baltimore and Washington) is also included, together with facts on the outstanding communities in which our staff members live.

Quantity is somewhat limited. May we suggest you send now to: Professional Staff Appointments,

The Johns Hopkins University
Applied Physics Laboratory

8643 Georgia Avenue, Silver Spring, Md.

when and where

JULY

Royal Aeronautical Society and British Interplanetary Society, Symposium on High Altitude and Satellite Rockets, Cranfield, England, July 17-20. Air Force Assn. Convention, Washington, D. C. July 30-Aug. 4.

AUGUST

IAS Naval Aviation Mtg., U. S. Grant Hotel, San Diego, Calif., Aug. 6-10.

International Ignition Conference, Bendix Scintilla Div., Sidney, New York, Aug. 20-22.

Western Electronics Show & Convention, Cow Palace, San Francisco, Calif., Aug. 20-23.

SEPTEMBER

Royal Aeronautical Society & Institute of Aeronautical Sciences, sixth International aeronautical conference, Folkstone & London, England, Sept. 1-15.

General Assembly of the Intl. Union of Geodesy and Geophysics (IUGG), Toronto, Sept. 3-14.

ASME Fall Mtg., Hotel Statler, Hartford, Conn., Sept. 23-25.

SAE Aeronautic Meeting, Aircraft production forum and aircraft engineering display, Ambassador Hotel, Los Angeles, Calif., Sept. 30-Oct. 5.

OCTOBER

National Electronic Conference and forum on electrical research, development and application, Chicago, Ill., Oct. 7-9.

Triennial Inspection of the NACA Lewis Propulsion Lab., Cleveland, Ohio, Oct. 7-10.

International Astronautical Federation, 8th Annual Congress, Barcelona, Spain, Oct. 7-12.

Society for Experimental Stress Analysis, National Fall Convention, El Cortez Hotel, San Diego, Calif., Oct. 9-11.

Canadian Institute of Radio Engineers, Convention-Exposition, Automotive Bldg., Exhibition Park, Toronto, Canada. Oct. 16-18.

Canadian Aeronautical Institute/IAS Meeting, Montreal, Canada, Oct. 21-22.

ASME Conference on new developments in the field of power. Americus Hotel, Allentown, Pa. Oct. 21-23.

Computer Applications Symposium, sponsored by Armour Res. Foundation, Hotel Sherman, Chicago, Ill., Oct. 23-24.

Aircraft Electrical Soc. Annual aviation display, Pan Pacific Auditorium, Los Angeles, Calif., Oct. 24-25.

Baltimore Section IRE, and the Professional Group on Aeronautical and Navigational Electronics, Fourth Annual East Coast Conference on Aeronautical and Navigational Electronics, Fifth Regiment Armory, Baltimore, Md., Oct. 28-30.

NOVEMBER

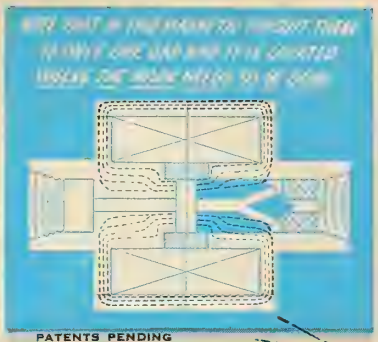
IRE-PGCS Third Aeronautical-Communications Symposium, Utica, N. Y., Nov. 6-8.

IAS Weapons System Management Meeting. Statler-Hilton Hotel, Dallas, Tex., Nov. 7-8.

National Defense Transportation Assn. National Convention, Shoreham Hotel, Wash. D. C., Nov. 18-21.

DECEMBER

ASME Annual Meeting, Hotel Statler, New York City, Dec. 1-6.



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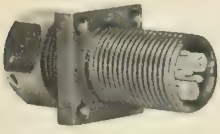


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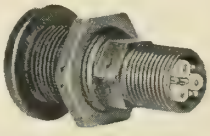
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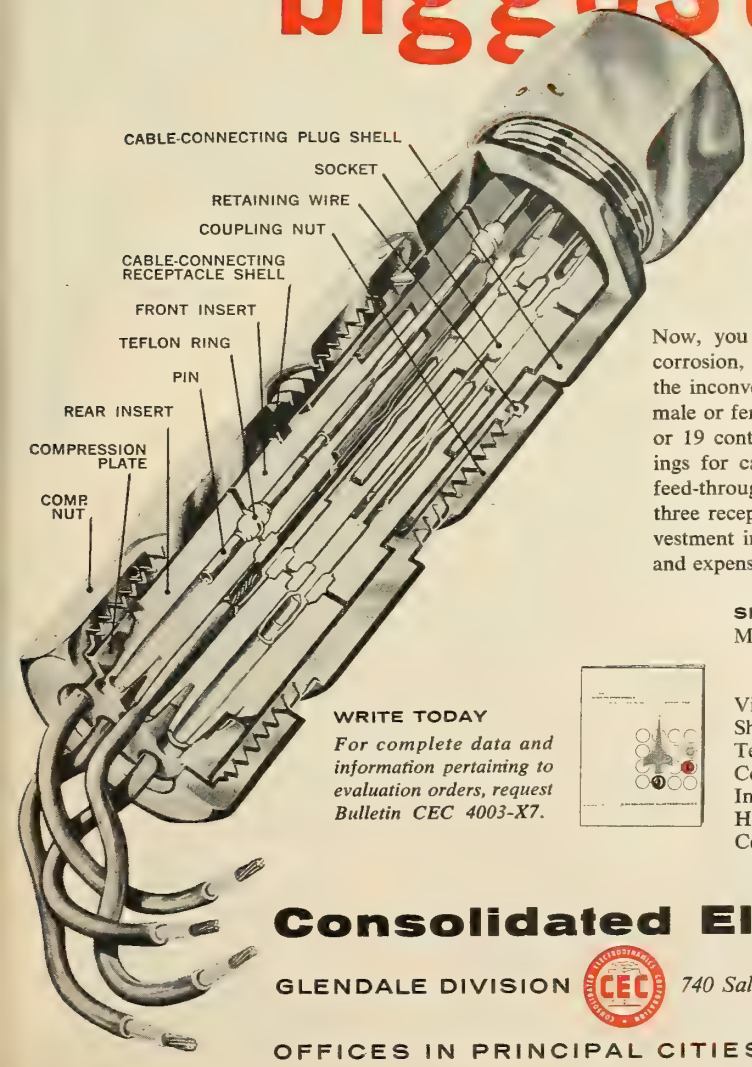
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Vibration.....No resonances to 2000 cps
Shock.....>200 g's
Temperature.....–67° to + 400°F
Contact Voltage Drop...<25 mv at 5 amps
Insulation Resistance.....$>10^6$ megohms
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Corrosion.....Salt spray per QQ-M-151a

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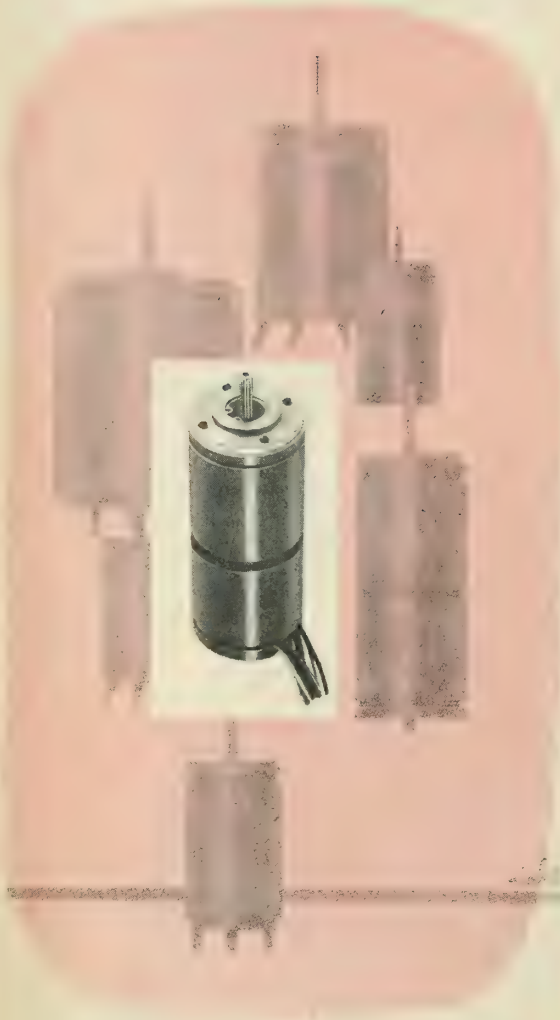
servo systems and components

The Edison Instrument Division is now offering design engineers an extensive line of miniature and subminiature Hi-Temp Servos and Servo Components . . . in addition to a complete facility for custom designed units and servo sub-systems.

Edison s Size 11 Motor Damping Generator for example, was built to such precise tolerances that a leading systems manufacturer was able to make this particular unit do double duty as a tachometer generator. This miniature unit's fast response and large output signal makes it ideal for applications where weight, size and high performance are prime requisites.

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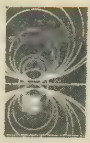


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TYPE OF MOTOR	TWO PHASE SERVO MOTOR-DAMPING GENERATOR
NO LOAD SPEED (MIN. RPM)	5800
STALLED TORQUE (MIN. OZ. IN.)	.60
POWER INPUT TO MOTOR AT STALL (NOM. WATTS/PHASE)	3.5
SPEED AT MAX. POWER OUTPUT (RPM)	3300
TORQUE AT MAX. POWER OUTPUT (OZ. IN.)	.31
THEORETICAL ACCELERATION AT STALL	34,800 RADIANS/SEC ^{2}
TIME CONSTANT	.019 SEC.
POWER INPUT TO GENERATOR AT STALL (NOM. WATTS)	3.5
OUTPUT VOLTS AT 0 RPM (MAX. RMS)	.019
OUTPUT VOLTS PER 1000 RPM (MIN.)	.5
PHASE SHIFT (MAX.)	10 DEGREES
DUTY	CONTINUOUS AT STALL

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letters

Space Age Definitions Needed by Truckers

To the Editor:

This Bureau is one of eighteen in the larger cities of the U.S. to assist both carriers and shippers in the proper description and packaging of motor freight shipments. Our Bureau recently subscribed to your magazine to help us keep abreast of technical developments in the missiles and rockets field, as well as related developments in electronics.

The National Motor Freight Classification provides a description for "projectile or rocket parts." It is therefore necessary for us to have a few definitions to work from. We wondered if you might be kind enough to help us define and distinguish between the following terms as they are correctly used in the industry: projectile, jet engine, rocket engine, rocket, missile, rocket-missile.

At one time we decided that "projectile" was a general term applied to any article which is moved abruptly into or through the air by any force. This meaning would include a bullet, an arrow, a sone form, a slingshot, a rocket or a missile.

At various times we have considered a "rocket" defined as a projectile driven by a special type of motor called a "rocket engine;" and, in contrast, a missile was propellant without the use of a rocket engine.

However, it now appears, from usage in your magazine and in the industry, that a missile is much the same as a rocket, except that it is always "guided." So, at this point, we are simply confused.

Your help in defining these terms will be appreciated by the whole trucking industry.

C. F. Sullivan,
California Trucking
Associations, Inc.
3301 South Grand Avenue
Los Angeles 7, Calif.

Insofar as possible m/r feels that any definitions in any new field, missiles, rockets and astronautics included, should stick to traditional definitions. A projectile, therefore, is (according to Webster) "a body projected by exterior force, and continuing in motion by its own inertia; specifically, a missile for a firearm or cannon." That definition could also include hurled rocks, arrows, spears and the warhead of a ballistic missile. A jet engine is, in general, any engine based on the reaction principle. Specifically, however, usage restricts it to those engines which carry only fuel and rely on the atmosphere for oxident—axial and centrifugal flow turbojets, pulsejet, ramjet. Briefly, a rocket engine also relies on Newton's third law of motion, except that a rocket carries its own oxident. Missile includes projectile but is broader, including anything that can be "thrown, hurled or projected" whether guided or not—such as pilotless aircraft, for example. Rocket-missile seems to be a redundancy or terminology.—Ed.

Wants Missile Films, Books

To the Editor:

Our management Club, at Douglas Long Beach, is one of the groups needing more information about the missile program. We are starting on the *Thor* ground support equipment and do not have an adequate background in missile science.

In the April issue of m/r you referred to booklets and films by Martin & General Electric. Could you please forward the addresses of those companies so that we can make arrangements for copies of the booklets and renting of the films.

E. E. Brockmann
Douglas Aircraft Co.
Long Beach, Calif.

Contact Tom Irvine, Manager, News Bureau, General Electric Company, Schenectady, N.Y.; and Joe Rowland, Manager, Public Relations, The Martin Company, Baltimore 3, Md.—Ed.

Wants Cover Shot for Framing

To the Editor:

Your magazine has been a source of much pleasure and information to me. I have been receiving MISSILES AND ROCKETS for several months now.

The cover of the June issue, with the space ship heading toward a galaxy, is truly beautiful. Can you send me a photograph or reproduction suitable for framing? I will be glad to pay any charge for this.

Leonard Busbee
1841 New Tampa Highway
Lakeland, Fla.

It's in the works.—Ed.

Says They Come First

To the Editor:

With reference to p. 84, April m/r, while we thoroughly agree with author Fred S. Hunter that Systems Laboratories Corp. has many distinguishing features, one of them is not that it is the first corporate organization specializing in interplanetary flight. We understand SLC was incorporated in May, 1956. The General Astronautics Corp. was incorporated under the state laws of New Jersey in February 1956, three months earlier. The situation is somewhat similar to two rocket companies: New Jersey's Reaction Motors, Inc has a slight edge in age over California's Aerojet.

Ronald C. Wakeford
General Astronautics
Oyster Bay, N. Y.

Wants to Fire 30-Mile Rocket

To the Editor:

You and your staff are to be congratulated on the marvelous job you have done in the compilation of such a great amount of material during the relatively few months that m/r has been published.

I was particularly impressed with the issue featuring "Modern Torpedoes and Underwater Missiles." Back in 1943 thru 1945 I worked on one of the first guided missiles. It, too, was designed to be launched from the air and then to strike its target underwater.

The driving force was a rocket motor. Unfortunately, the project was not completed in time to be effective, and as far as I know has never been released from security.

The Rocket Research and Development Society of Houston, Tex. of which I am technical director, has a problem for which you may be able to give some advice.

This group is very active in the engineering of rockets and missiles and I

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am sure that their efforts in the future will result in more rapid and efficient solutions to the problems that exist in this field.

However, we do not have an adequate firing range where we can accurately check performance. If at all possible, we would appreciate the opportunity of firing our 30-mile missile at some facility equipped for this type of work.

We have already contacted Lt. Col. James P. Hamill, Chief Ordnance Mission at the White Sands Proving Grounds but were informed that the Department of Defense regulations do not allow private groups to use that firing range.

If there is anything you can do to help us locate some facility where we would be permitted to fire our missile under controlled conditions, it would be deeply appreciated.

Ten or twelve boys would want to participate in this firing activity.

L. F. Megow
Rocket Research &
Development Society
3342 Arbor Ave.
Houston, Tex.

See Missile Miscellany, page 168, and write Mr. Foster Haley, Office of Public Information, Redstone Arsenal, Huntsville, Ala. He may be able to help. He'll try anyhow.—Ed.

Subject: Article entitled "Project Vogelhundt"

To: Missiles & Rockets Magazine

1. The attached material was submitted to this office for security review and clearance for public dissemination.

2. The statement in paragraph 1 of the article indicating that the project comes under the cognizance of the Naval Ordnance Test center appears to be in error. NOTC informs this office that while the project borders upon PROJECT SMISH, which, as you know, is highly classified, it in no way overlaps or invades that field.

3. Consequently, the Navy Department has no objection to publication on grounds of security. However, it is suggested that MISSILES & ROCKETS Magazine, in keeping with its policy of obtaining official clearance for its material, submit article to the U.S. Army Canine Corps (QM) and/or the U.S. Air Force Strategic Air Command (Security Division).

4. For your information, it is believed that original research on olfactory processes and particularly on Bassett Male Aero Bark X3A was conducted by Army with technical assistance from the Seeing Eye Dog Foundation. Research on the Mark IV version was taken over by Air Force SAC in connection with its program of security for bases.

5. Early in 1956 it was determined that Bassett Female Yipe 6 and setter Female Yipe 8 appeared to be far more productive than the X3A and Mark IV versions of Bassett Aero Bark and that the end product was less subject to infestation by parasitic bosphoetai. Further and more detailed data on additional expermentation should be obtainable from the two services mentioned.

6. Regarding the alleged accidental firing of Project 73, which the article states, landed in the Panamint Range, it is suggested that this matter be referred to the Department of the Interior.

R. A. Barracks
Cmdr. USN
Chief, Navy Branch
Office of Security Review
Office of the Assistant
Secretary of Defense
Washington 25, D. C.

New readers see "letters" in m/r's May issue. Project Vogelhundt was submitted to Department of Defense Security Review, according to a long-standing m/r custom of never publishing any document that we have not cleared. After much serious consideration on the part of those charged with safe-guarding our security, m/r received this "official" clearance from a Navy Commander who (bless him) has a sense of humor.—Ed.

The Challenge of Gravity

To the Editor:

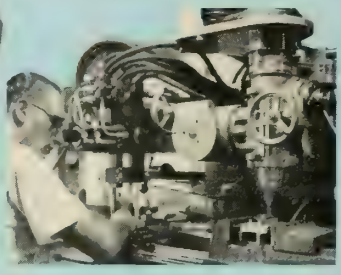
If it were possible to select a best issue from among the fine presentations which the m/r staff has put out every month, my vote would go to the recent June 1957 issue. The article entitled "Seven League Boots" by Seabrook Hull brings to the fore a subject which many have puzzled over but which relatively few have ever put any real effort into: gravity.

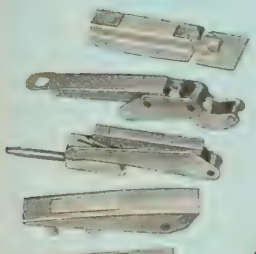
Please understand that aside from having the tools of an engineering degree and eight years experience in the consulting field my only familiarity with the subject comes from studying the works of others and a very slight amount of original thinking and calculation.

Being convinced, however, that the key to the great revolution in man's approach to his environment is hidden in the term gravity, it is my purpose to add

PUT HARTWELL TO WORK
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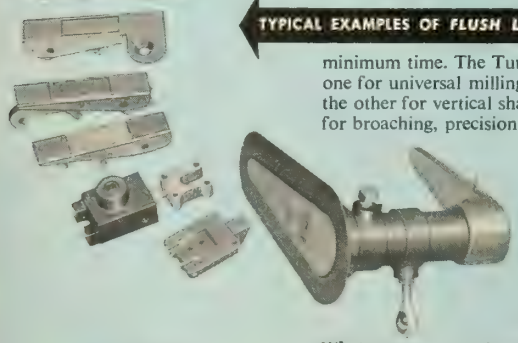




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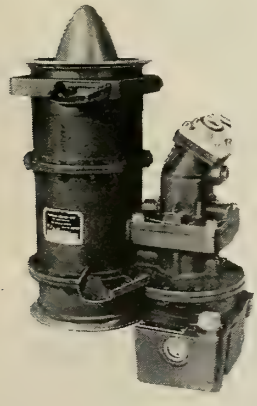
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letters

whatever meager help I can toward the solution of the mystery.

Not being one of the small group of particularly qualified men, I am interesting myself with the problem of stirring up interest among the larger group. Interest in any subject increases as one's knowledge of the subject increases. Obtaining knowledge on the history of research and development in the field of gravity is not impossible but is time consuming and sometimes rather discouraging. Except for a chapter in a physics text or a very involved mathematical treatise by Einstein most of the material is pretty well scattered.

There is no book available, according to the Massachusetts Institute Bookstore, devoted to the subject of gravity exclusively. I am therefore engaged in the compilation of such a book which I hope will serve as an introduction to the subject to many uninitiated but fertile minds.

The book will not be the presentation of original material but rather will be a review of the study of gravity from the earliest times to the present. It will include as complete a bibliography as possible of all articles and publications dealing with the subject. Excerpts or abstracts from these publications will be included (depending of course on the authors' and/or publishers' permission).

It is hoped that this book will excite the interest and imagination of at least a few capable young people to the point where they will take up the ball and devote their efforts to this problem.

I am fully aware that several well financed projects are currently under way and that they are manned by very capable men. It is my belief, however, that this small task force needs many new recruits to win the battle.

In order to make this book as valuable and complete as possible I earnestly solicit your comments and criticisms as to the undertaking itself and with reference to the type of material which you think should be included. I also request permission to reference your article (with proper credit).

Any information such as possible sources of information or parties who might be willing to assist this project in any way will be sincerely appreciated.

A "well done" to the entire staff of m/r. Keep up the good work.

William S. Alcott
49 Blackhawk Road
South Weymouth, Mass.

A letter follows. Good luck.—Ed.

Future Missileer

To the Editor:

I could point out more than one reason why I subscribe to your magazine, but they all would boil down to one: My great interest in the subject which is more than anything else symbolic of the world's progess and of the continuous effort to intensify the relations among peoples.

I am only a high school student but next year I will attend Rome University's Faculty of Aeronautical Engineering. I will thus be able to devote myself entirely to this subject.

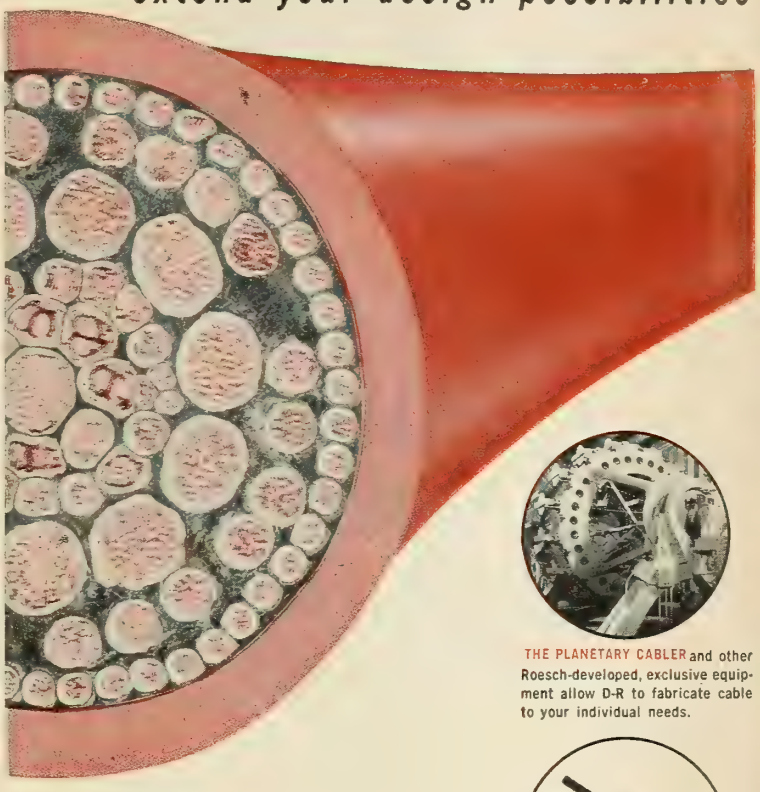
It is my intention to take up a finishing course and work in the U. S. after acquiring my degree.

Albert Arcangioli
Viale Parioli, 81
Rome, Italy

DOUGLAS ROESCH

Custom ELECTRONIC CABLES

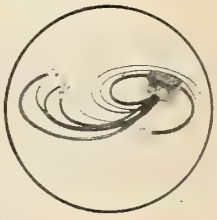
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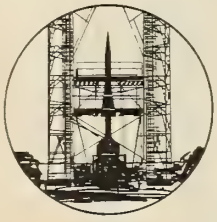


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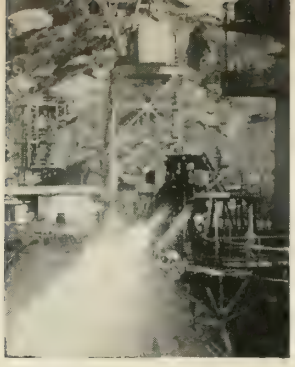
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performance test

Brush Recording Systems at Rocketdyne, a Division of North American Aviation, Inc., directly record stress, acceleration, and acoustic values of rocket engines under test.

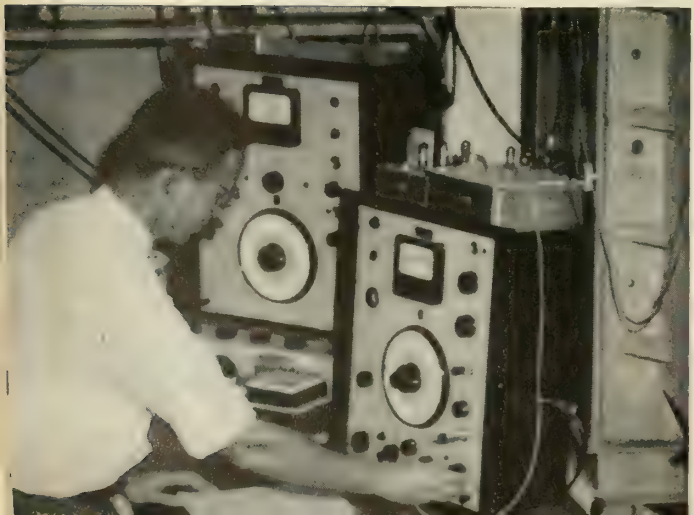
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When selecting recording instrumentation for either military or industrial research and development, you want equipment that is proved by experience. Remember—there are more channels of Brush direct-writing oscillographs in use than all other makes combined.

This equipment offers the widest range of recording speeds available, to provide excellent readability for a wide range of signals. You have a choice of ink writing or electric writing, available in console, rack mounted or portable units.

The direct-writing frequency range, from d.c. to 100 cycles per second, covers the great majority of requirements for measurement of physical phenomena. Thus you can instantaneously record stress, strain, vibration, torque, force, and many electrical variables. Select *BRUSH* for equipment backed by unmatched experience.



complete frequency spectrum analysis for noise tests

With a Brush-Bruel & Kjaer Spectrum Recorder, a complete frequency spectrum analysis can be performed in a matter of seconds. This instrumentation operates *automatically*—thus saves hours of engineering time. And it presents recorded data in one-third octave steps—a form in which information is most meaningful and useful to noise reduction programs.

Shown at left is an aircraft test setup measuring loss in acoustic transmission through fuselage wall panels. This is one of scores of complete systems for sound, noise, or vibration analysis using Brush-Bruel & Kjaer equipment.



Official photograph U.S.N



telemetering

Over 100 Brush units at the Naval Air Missile Test Station at Pt. Mugu directly record data telemetered from missiles such as the Regulus I. Instruments record an almost limitless variety of functions and conditions, including pitch, yaw, acceleration, pressure, strains, etc.

For complete information contact your Brush representative or write Dept. M-7

BRUSH ELECTRONICS COMPANY

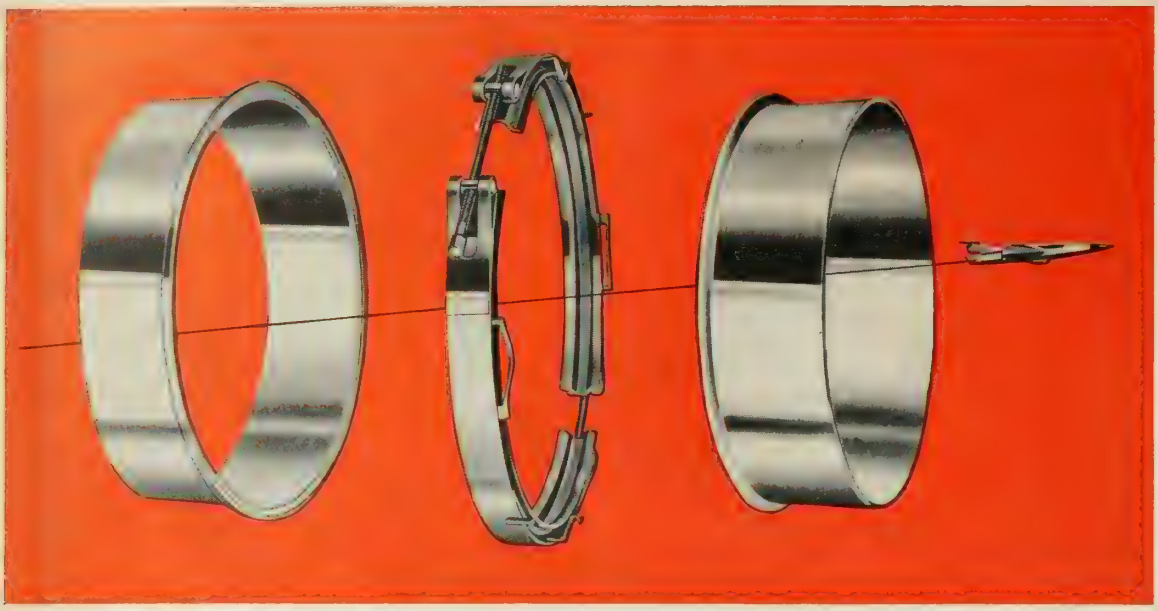
3405 Perkins Avenue, Cleveland 14, Ohio

DIVISION OF CLEVITE CORPORATION

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NEW MARMAN CONOSEAL TUBING JOINT

ASSURES PERFECT FLUID LINE SEAL AT EXTREME TEMPERATURES AND PRESSURES



HIGH PRESSURE PNEUMATIC SYSTEMS
LIQUID OXYGEN SYSTEMS
HYDRAULIC SYSTEMS
EXHAUST SYSTEMS
FUEL SYSTEMS

Operating Range	Temperature Range (° F.)	Max. Pressure (3" Size @ 70° F.)
Low	−300 to +750	1300 psig.
Medium	−300 to +1000	3300 psig.
High	−300 to +1600	testing still in progress

A 2½" Conoseal Joint has been tested with end restraint up to 6,000 psig.

Conoseal is an Aeroquip Trademark.

Problems of connecting tubing and ducting of dissimilar metals subject to extreme temperatures can be solved with the new Marman Conoseal Tubing Joint. An all-metal joint, it provides metal gasket compression with the flexibility and sealing qualities formerly obtained only through use of organic seals. The Conoseal Joint withstands axial deflections up to 1/16-inch without sacrificing a perfect seal. The seal is maintained under extreme pressures and temperatures even on joints with material transitions, in which steel and aluminum alloy plumbing are joined.

The Conoseal Tubing Joint is available in three different operating performance ranges to meet varied applications. Standard sizes from 1" to 12" O.D. tube size, with special sizes designed to your requirements. Write today for full engineering details.

MARMAN DIVISION
Aeroquip Corporation

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MARMAN PRODUCTS ARE MANUFACTURED UNDER VARIOUS U. S., CANADIAN AND FOREIGN PATENTS AND OTHER PATENTS PENDING

Circle No. 19 on Subscriber Service Card.

LIQUID Oxygen TEST LOOP

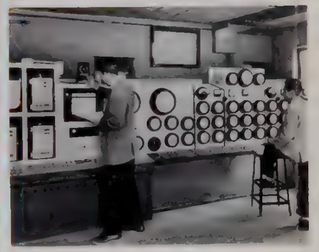
JP FUEL TEST LOOP



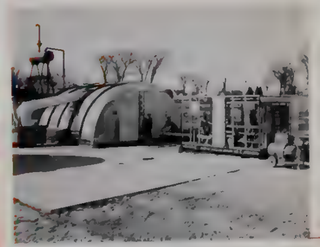
Aerial close up of Liquid Oxygen test site. Note 65 foot tower mounted tank to simulate actual head pressure requirements.



View from south side showing Tank Farm.



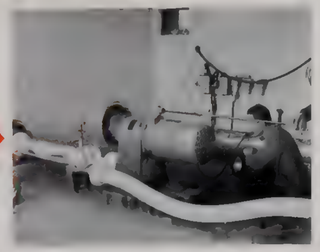
Instrumentation and remote operating console inside Liquid Oxygen Test Loop Blockhouse.



View from east of full scale environmental qualification test of 1000 GPM RP Fuel Transfer system.



Full scale cycling test of 1000 GPM remote Operating Liquid Oxygen Transfer System.



Full scale life test on 250 GPM Topping Pump.



Reliability tests of 4000 gallon Liquid Oxygen missile fueling semi-trailer.



Pressure transfer evaluation using 300 PSI Liquid Oxygen Converter flowing into tower tank.

FACILITIES



Life test of remote operating Liquid Oxygen valve.



Flow and pressure testing of high pressure vaporizer.



Flow testing of Liquid Nitrogen pressurizing system.



Control and sample panel of air separation column.

EXPERIENCE

FLEXIBILITY

If your product development planning requires a program for qualification or reliability testing to Military Performance Standards involving service with Liquid Oxygen, Nitrogen, Argon or Hydrocarbon Fuels, please indicate your interest below.

A Cambridge Representative is available to discuss R1 and R2 applications to your program.

Type of Test	*Problem Area*	*Facility Required*
☐ Qualification Testing	☐ Systems	☐ R1 Liquid Oxygen
☐ Reliability Certification	☐ Components	☐ R2 JP-RP Fuels
☐ Environmental Testing	☐ Materials	

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R1
R2
CAN HELP YOU

tured here are the stepping stones to achievement of product depend-ility. Conceived in research and design; approved for application ough testing; Cambridge Systems acceptance is in large measure a sult of extensive testing, retesting and more testing.

e invite you to use our FACILITIES, EXPERIENCE and FLEXI-ILITY in your product development program.

For your convenience you may express your interest on the reply card below:

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LIQUID OXYGEN TEST LOOP

PROJECT R1 R2

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Open Letter to Industry

Subject: Project R-1
Project R-2

Gentlemen:

Some twenty months ago, our Company as a participating member of the industrial team involved in the Air Force Missile Program, was faced with the need for full scale cold flow testing of large missile oxygen prototype systems. At that time, we undertook an extensive survey to determine the available capabilities both at government and commercial installations for such testing. We found that tight schedules prohibited the possible use of government facilities and no commercial facilities existed. As a result, Cambridge Corporation inaugurated two projects directed toward achieving complete full scale testing capability for liquid oxygen and JP fuel support systems.

These facilities, as described in this folder, are now available to anyone active in the missile program or in the commercial oxygen industry.

Your interest is invited and can be expressed on the reader reply card attached. You may be assured of our whole hearted cooperation and assistance.

Very truly yours,

CAMBRIDGE CORPORATION

J. W. Logan
President

Missile Business

By Seabrook Hull



FOREIGN MARKET FOR U. S. MISSILES in next two years will total $300-to-$500 million. This is the missile build-up phase of the Mutual Defense Assistance Program. Once the pipeline is filled, the maintenance and modernization level-off rate will run about half that.

Nearly every type of U.S. missile is potentially involved. First interest, however, is in air-to-air, ground-to-air, tactical surface-to-surface and Intermediate Range Ballistic Missiles. Main markets are Western Europe, Australia and Japan. In the beginning, direct sales and grants to other countries will be minor.

Only real potential competitors U.S. missile-makers face at the moment are Britain and France, and even they won't build big missiles like IRBM's. At this writing, no U.S. missile company plans production abroad. Reason is severe initial capital cost. To a large extent, U.S. sales abroad will involve only the basic piece of hardware plus a minimum of spares. MDAP planners hope for local-country servicing, manning, maintenance and operation. U.S.-supplied nuclear warheads will remain U.S. property under the law but will be stored "just over the fence" from U.S.-made, foreign-owned missiles.

COMPETITION FROM BRITAIN will come primarily in air-to-air and surface-to-air missiles. Here, the British nearly match U.S. in some cases; are ahead in others. British appear particularly hot on terminal guidance, but lag in ground-control techniques. British hope their ability to produce less complex missiles at lower cost will be sales advantage. Foreign buyers are more price conscious than U.S.

AIR FORCE IS WORRIED ABOUT MISSILE COSTS. At recent briefing top AF officials told 100 representatives of 51 major contractors that future business would go where prices were lowest. Maj. Gen. David Baker, AMC Procurement Director, deplored current high costs.

BIG MISSILE NEED IS PRODUCIBILITY. This means taking a tip from auto-makers and other mass production manufacturers. Tendency now of taking an R & D vehicle and ordering it into production substantially unchanged must stop. One answer is to put the manufacturing department on an equal footing with the designers. Another is to improve liaison between designer and producer. Designer's lack of knowledge of optimum production methods and producer's ignorance of design and operational requirements are, generally speaking, appalling.

DON'T WORRY about Defense Secretary Wilson's $38 billion ceiling on defense spending. Object's to avoid a deficit national budget. Treasury Secretaries traditionally over-estimate expenditures and under-estimate tax revenues—Humphrey more than most. The money's there and will be forthcoming if needed to keep missiles on schedule.

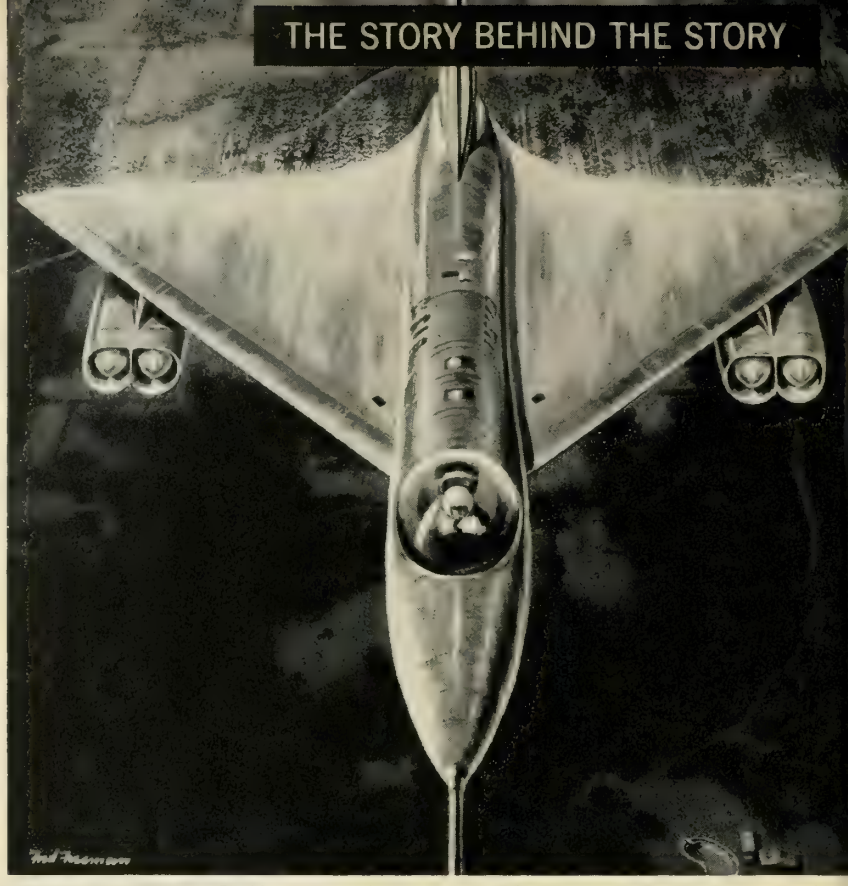
SOME MISSILE PROGRAMS WILL BE CHOPPED, however. White House has ordered end to missile bickering; claims it jeopardizes national security. Result: Wilson has ordered crash review of all missiles, particularly IRBM's *Jupiter* and *Thor*; wants action in 30 days.

SINGLE MISSILE R & D AND PROCUREMENT AGENCY may be result. This probably would mean wedding of AF Ballistic Missile Division and Army's ABMA into single-service R & D operation, not dissimilar to NACA—as suggested first by m/r in January. There are strong views that this should be non-service—neither AF nor Army.

VISIT OF 19 TOP AF BALLISTIC MISSILE EXPERTS TO REDSTONE, including Maj. Gen. Bernard S. Schriever, for complete exchange of technical information may mean IRBM nod for *Jupiter*.



MISSILE CRUISER Problem: To launch a missile 1500 miles from target. An error of only 1 degree in launching information would cause a 25-mile target miss.

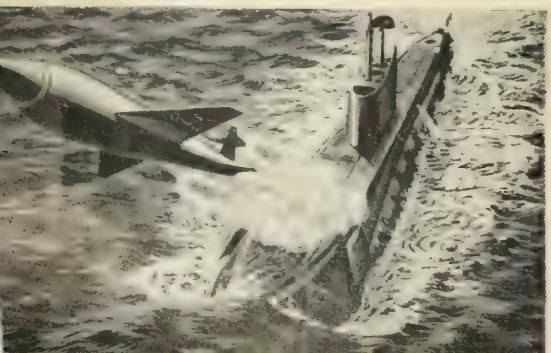


SUPERSONIC BOMBER—Problem: To navigate undetected for thousands of miles to exact position in space for release of bombs or missiles.

INERTIAL NAVIGATION:

In Its Accuracy Lies Power for Peace

ATOMIC SUBMARINE— Problem: To travel submerged for days and know exact spot to surface for missile firing.



U. S. strategy for maintaining peace by making aggression unprofitable is based on our ability to deliver a crushing retaliatory blow anywhere in the world. Accurate means of directing such blows at long range, high speeds and extreme altitudes make would-be aggressors wary of breaking the peace.

To be effective, weapon carriers must know at all times *exactly* where they are. For example, the long-range bomber with its pinpoint target or the pitching cruiser launching missiles far at sea must navigate with great accuracy.

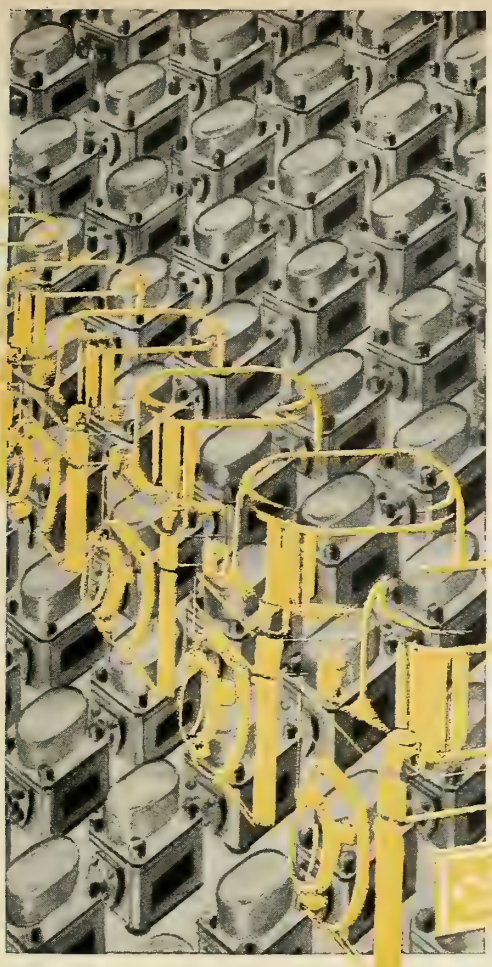
Solving such problems is the task of Inertial Navigation systems which furnish all data required *automatically*. Completely self-contained within the bomber, ship, submarine or missile, these Inertial Navigation systems require no contact with ground stations. This is extremely important when military missions must be carried on without chance of detection.

To design and engineer Inertial Navigation systems involves a complex combination of engineering skills—gyroscopics, computation, electronics, servomechanics and more. Their production calls for laboratory precision at every stage. For example, the gyroscopes which form the heart of Inertial Navigation systems must be many times more accurate than those used in commercial navigation.

At Sperry, Inertial Navigation systems are being produced for a wide variety of military applications.

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Army to Launch Second Jupiter "C"

Army Satellite Tracking System Revealed

HUNTSVILLE, Ala.—An apparent speed-up of test firings at the nearby Redstone Arsenal and ABMA facilities in recent days has led to speculation that a second version of the *Jupiter "C"* is being rushed to completion.

The rumblings and subdued roars of tests from the huge stands at the arsenal have become longer and louder during the past few days, surpassing anything to which local citizens have become accustomed during the past five years. The tests can usually be heard in the city, several miles away, during mid-afternoon. Occasionally there is a second test in the late afternoon. They usually can be heard for about one minute.

In early June, one test began at about 4:30 P.M. but it ran more than twice the "normal" length of time. One citizen who timed it said the final cut-off occurred 162 seconds after the first sound was heard.

The first *Jupiter "C"*, an experimental stage-rocket device consisting of a *Redstone* booster and two stages of clustered solid-propellant rockets was fired last September from Patrick AFB, Florida. Reportedly the missile traveled 3,300 miles and reached a peak altitude of between 650 and 680 miles.

A small payload containing a radio transmitter and other instrumentation was supposed to have been tracked "all the way." Reliable sources say the first *Jupiter "C"* could have brought its payload into an orbit if the final stage trajectory had been preset accordingly. Apparently, the final stage of the *Jupiter "C"* brought the payload down in a powered trajectory rather than in a ballistic path.

The *Jupiter "C"* test vehicle was developed by the Army and Jet Propulion Laboratories to study missile staging and separation techniques as well as guidance, telemetering feedback and tracking.

Some sources have hinted that the second *Jupiter "C"* might put its payload into an orbit around the earth when it is fired shortly. The Army is interested in proving that they are capable of supporting any satellite experiment with current Army hardware. The first artificial satellite project undertaken in this country under the code name "Project Orbiter" was to have used the *Redstone* missile as a first-stage booster and a cluster of *Loki* solid-propellant rockets as the second stage. The project was cancelled when the Government announced Project *Vanguard*.

The Army's own satellite tracking system was put on display at the recent National Telemetering Conference in El Paso, Texas as the subject of a display sponsored by Jet Propulsion Laboratory.

Designed by JPL, the tracking system is known as Microlock. Main features claimed are ultra-high sensitivity, light weight and long life.

A transmitter for satellite use is contained in a small cylinder and will radiate a signal for three months and weighs 2 pounds. It provides two narrow band telemetering channels.

Tracking for a distance of 3000 miles using Microlock "at any azimuth or elevation angle" is claimed. Reportedly, JPL's satellite system was used in the altitude and distance record breaking flight of Army's first *Jupiter "C"*. Signals from JPL's electronics on board were received to point of impact.

Production of Microlock systems for Army use as beacons in missile testing is under way at Motorola, Inc.'s Military Electronics Division in Phoenix, Arizona.

USAF Assumes Responsibility For ABMA

HUNTSVILLE, Ala.—The Air Force and the Army may have buried the hatchet in their bitter *Thor-Jupiter* IRBM dispute as the result of the visit here June 19 and 20 of Maj. Gen. Bernard A. Schriever, commander of the USAF's Air Research and Development Command's Ballistic Missile Division.

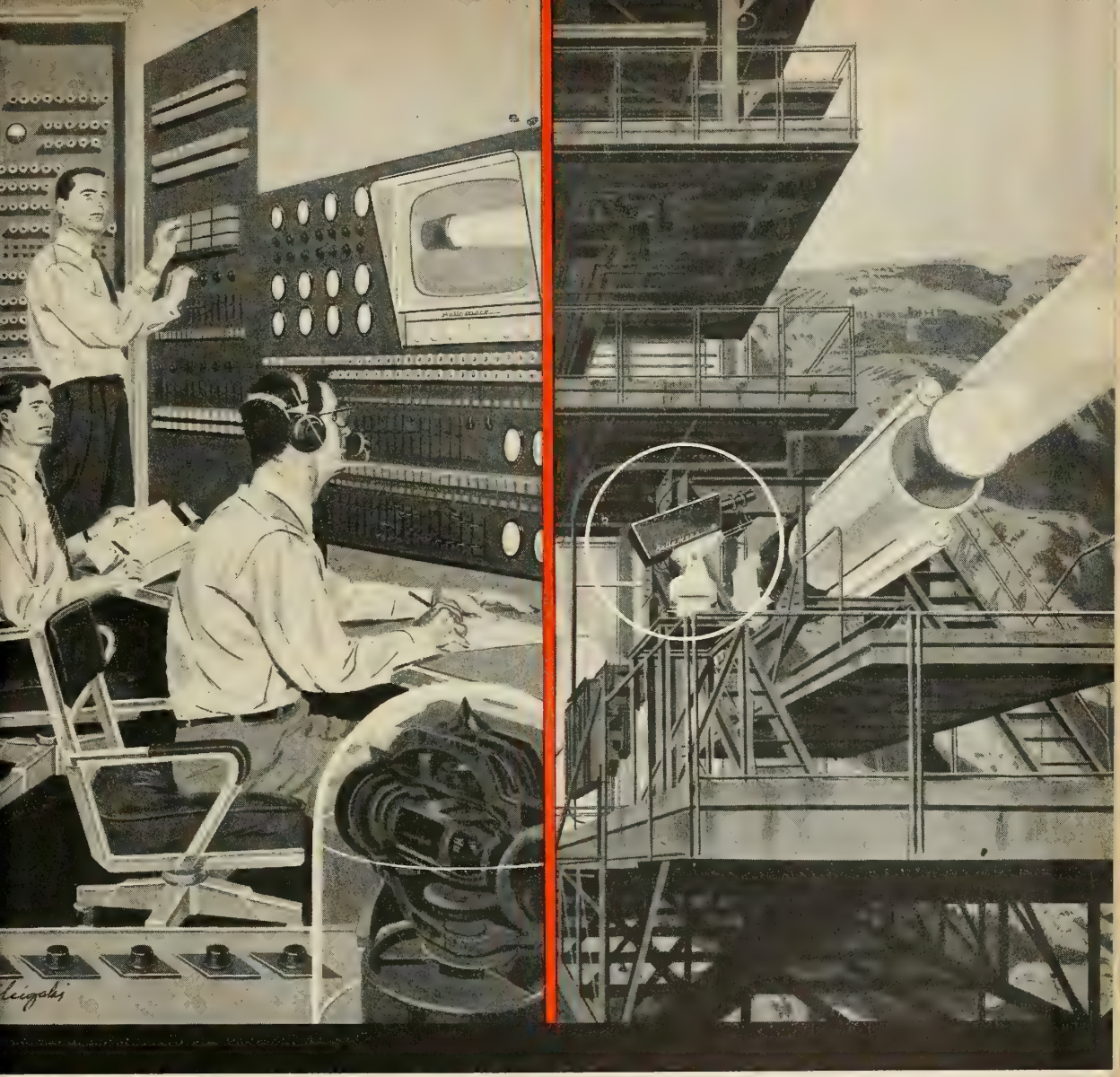
The Air Force assumes financial responsibility for IRBM work at the Army Ballistic Missile Agency as the government's fiscal year of 1958 begins on July 1st.

Schriever and a large staff of USAF missile officers visited with ABMA commander, Maj. Gen. John B. Medaris, toured the complete ABMA and Redstone Arsenal installation, watched the work on the Army's *Jupiter* IRBM and saw test firings. It was Schriever's first visit here.

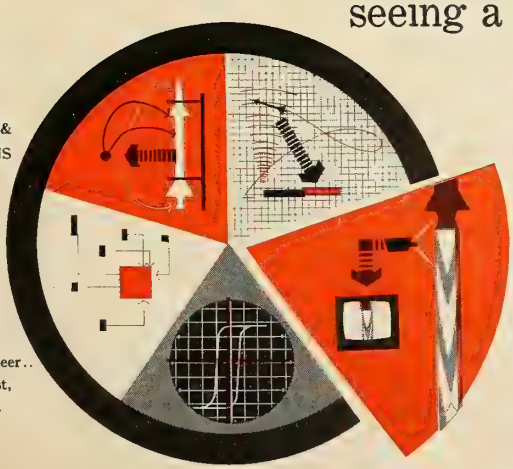
There has been persistent rumors that USAF officers had previously been denied full briefings on the *Jupiter* by the Army, but this was denied by both services.

A brief communique issued by Schriever and Medaris said:

"There has been a complete interchange of technical information in the IRBM developments between the Army and Air Force commands responsible for them. The sole interest of both services is to provide the best IRBM at the earliest practicable date, in the urgent interest of national defense. It is to achieve this objective that we have committed all the resources in manpower, facilities and funds provided for the purpose. Out of this joint effort will emerge the weapons system determined essential to the security of our country."



seeing a hot one...on Hallamore captive T



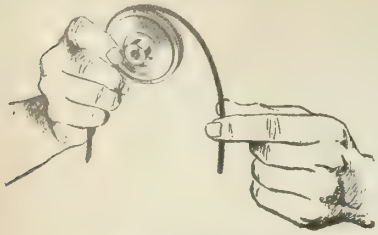
Far too hot, and positively too ear-splitting, for close, on-the-spot observati by human beings...when high thrust propulsion units are fired up for test, Hallamore closed-circuit television takes over the job. Throughout industry similar Hallamore systems are finding application...wherever the requirem is for remote observation or for fast transmission of visual impressions. Hallamore Electronics designs, develops and manufactures missile ground support and in-flight instrumentation systems, magnetic products, electroni components and audio visual communications systems. Current activity includes contracts for the United States armed forces and prime contractor of the aircraft and ordnance industries.

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CONTROL LINKAGES

The unusual cable shown above is Teleflex—the unique "flexible rack" that is helping to solve mechanical motion problems up to 1,000°F.

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PROBLEM: A highly accurate mechanical feedback linkage is required to complete a servo system loop. One end of the system is exposed to a 350°F ambient temperature.

SOLUTION: A special control box was designed, with a hobbed wheel to engage the Teleflex cable. A spring-loading feature allows for a selection of spring loads up to 25 pounds, applied in either direction, depending on the individual mounting arrangement or system load. One system over 100 inches long, with 270° of bend, had only .022 inches of backlash. Under more favorable bend and length conditions, another system held backlash down to .005, using a similar control box.

Teleflex tubular conduit, routed along contours and around obstructions, guides the cable to remote locations, duplicating the motion at both ends of a system.



DESIGN ENGINEERS—Complete descriptive information is in Catalog 500 L. Write for your copy to Teleflex, Incorporated, 125 S. Main St., North Wales, Pa.

TELEFLEX
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Circle No. 51 on Subscriber Service Card.

Second Atlas Ready to Go Next Month?

M/R has learned reliably that the second *Atlas* ICBM is scheduled to be fired at Patrick Air Force Base next month. This is a positive indication that the present state of the *Atlas* development program is proceeding on or ahead of schedule.

Some sources felt that the recent firing was made under pressure in order to expediate the state of the art evaluation of the nation's top priority program. The recent highly publicized misfires of the *Thor* and *Jupiter* IRBMs has led the uninformed press and the public to the conclusion that our long-range missile program is in serious trouble. Scientists and engineers close to the U.S. missile program since its inception shortly after World War II are not alarmed.

Many of this country's missile projects have suffered from growing pains similar to those of the *Atlas*, *Jupiter*, and *Thor*. No informed citizen would have quibbled over the setbacks and costs of the atomic Manhatten Project. Yet, our position in developing the ICBM is the same as with the atom bomb: national survival is at stake. In the latest analysis the first *Atlas* launching was very productive, yielding a wealth of data invaluable to the follow-up flights.

Air Force officials have disclosed that the *Atlas* misfire was due to a malfunction of a propellant turbopump. The numerous pre-flight checks and static firings proceeded with only minor difficulties. Testing began the day before the firing and continued throughout the night. Faults in circuitry check out were corrected with minimum delay. Flight program called for test of the two 100,000 lb. thrust booster rocket engines with a calculated range of over 2,000 miles climbing to an altitude of approximately 400 miles.

Engine ignition functioned perfectly and the *Atlas* lifted in vertical ascent with the twin booster engines thrusting equally. At an altitude of approximately 8000 ft. the flow of propellants to one engine was disrupted. The unbalanced thrust resulting from the enequal burning threw the missile into a yaw with a resultant loop. Guidance control responded instantly and corrected the *Atlas* to its vertical attitude. This maneuver was repeated twice more before decision was reached to activate the destructor system. At the time of destruction the missile was earthward bound with a possible impact upon the launching site.

Convair, North American's Rocketdyne Division and General Motors AC spark Plug Division are to be commended for the smooth handling of the preparations and launch of the expediated *Atlas* firing. Investigation of the history of prototype liquid propellant rocket firings uncover a record which clearly pinpoints a high percentage of failures. The probability of failure increases when pressure is exerted upon designers, production and test personnel.

The Air Force has announced that large scale testing of the *Atlas* ICBM will get under way next fall indicating that the 100 ton missile will be rolling out of the Convair plant on a quantity production basis. Additional tests will probably be run on the booster configuration before a three-engined maximum range will undoubtedly be conducted during the tests this fall.

Air Research & Development Command revealed that six specially equipped tracking ships will be stationed in the South Atlantic to fill in gaps extending out along the planned 5000-mile range. The ships will be positioned over the ocean extending from the last Caribbean station on the island of St. Lucia to the station on Ascension Island.

The ARDC statement confirmed the reports that the *Atlas* firing program will proceed on schedule. The launching of the *Atlas* was notification to the world that the ICBM program has come a long way. The coordinated efforts of the Armed Forces and American industry has proved many times in the past that any technological challenge can be met.

AF Officials Check ICBM Engines

Brig. Gen. B. I. Funk, deputy director, Ballistic Missile Office, made his first inspection recently of the new North American Aviation rocket engine factory and test station at Neosho, Mo. He was accompanied by Col. Samuel Bishop, Col. Sherman Ellis and Col. Albert Shumsky, chiefs of procurement, production and logistics in the BMO at Inglewood, Calif. The Air Force officials were briefed on the progress of construction and production at the Missouri facility by C. W. Guy, assistant general manager of Rocketdyne; J. P. McNamara, Neosho plant manager, and E. A. Wright, factory manager.

SAC Officers Briefed On SM-62 *Snark*

A series of four special courses on the *Snark* SM-62 is being given to key officers and civilians from Strategic Air Command units across the country, including the headquarters at Moffett Air Force Base, by Northrop Aircraft's training services section at Hawthorne, Calif. Selected representatives from the Air Training and Air Materiel Commands also are taking the training.

Program is designed to familiarize the group on the overall weapon system, including the missile, ground support equipment, depot operations, field service, mission, planning, publications and training. Instruction is aimed to provide a knowledge of the *Snark* from an administrative standpoint.

Beech Unveils Reconnaissance Drone

Beech Aircraft has taken the lid off its Model 1013 combat reconnaissance drone which is adapted from the company's model 1001, Navy XKDB-1 target plane.

Designed for airplane or ship launch, Model 1013 is powered by a 110-hp McCulloch engine. It grosses 800 lbs, has an operational speed of 260 mph and a service ceiling of 22,800 ft.

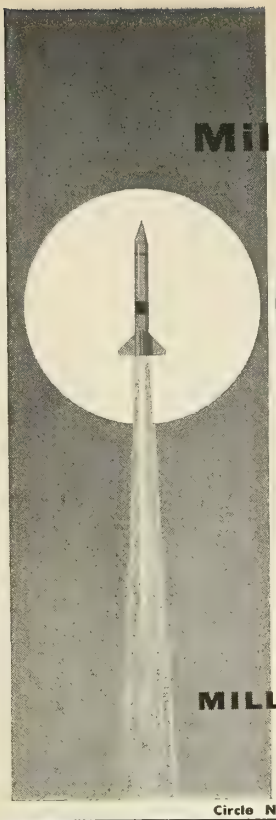
Beech said that first free flights of the XKDB-1 were made recently at the Navy Air Missile Test Center. It is currently undergoing contractor development testing to evaluate performance, radio guidance and recovery characteristics. It is propelled by a 120-hp McCulloch engine, has a speed of 320 mph, ceiling above 40,000 ft. and grosses 600 lbs.

Titanium Price Cut 10% by TMC

Titanium Metals Corp. has announced a 10% cut in the price of titanium products effective June 3 and applicable to a large backlog of orders of aircraft, jet engines, guided missiles, chemical process equipment, electronic and ordnance equipment.

The reduction is an across-the-board average, varying with the product. Commercially-pure sheet and strip are down $1.50 a pound; plate, 50¢ to $1.25 a pound; bar, 95¢ a pound; billets, 85¢ a pound; wire, $1 a pound.

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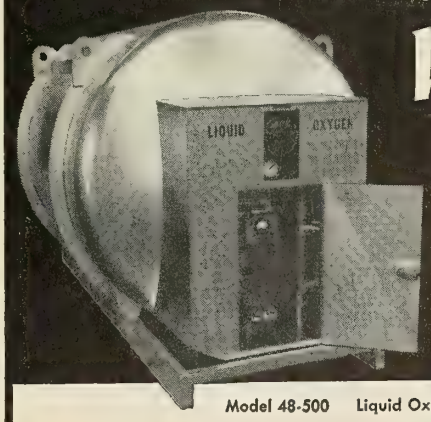
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U.S. Army Building 2000-Mile Missile

The Army may not be allowed to use them, but nobody has said catagorically that they can't build them. So Army's going ahead researching and developing a whole family of solid and liquid propellant missiles, ranging from small tactical stuff like *Honest John*, *Little John* and *Lacrosse* to 300-mile *Redstones* 1650-mile *Jupiters* and 3300-mile *Jupiter-C* test vehicles.

In addition, however, the Army Ballistic Missile Agency at Redstone Arsenal, Huntsville, Ala., is filling some gaps. Reported to be among the gap-fillers are a 2000-mile range Thiokol solid propellant ballistic missile nick-named *Big "B"* (Bee?) and a 750-mile missile possibly called *Little "B"*.

This work is significant in more ways than one. First of all, it's good evidence that the Wernher von Braun team of Army missile-makers hasn't let the furor of the AF-Army missile squabble deter them from the primary task at hand—to make bigger and better missiles and to thus pave the way to space flight.

Secondly, the Army which has traditionally favored liquid propellants for long range missiles, is suddenly turning to solids. This is proof of Redstone Arsenal's acceptance of the progress made in this field in recent months. The advantage of solid propellants for service missiles is obvious. Support equipment required in the way of LOX generators, liquid fuel carriers, etc., is less. There is also possible a greater state of readiness with solid propellants. The problem, of course, is stable storage for long periods.

Both *Little "B"* and *Big "B"* are in the prototype hardware construction stage. All reports indicate they are being developed as weapons rather than as research or test vehicles. Though these programs were probably conceived, approved and given tentative funding prior to the issuance of Defense Secretary Wilson's famous November Memorandum, the fact that the Army is continuing their development implies: First a faith that Army will ultimately be given operational authority to use them; and second, that the Department of Defense is aware of the projects and has okayed them.

It is perhaps ironic that the Army should now be going ahead full blast with the development of solid-propellant long range missiles. It was the alleged Navy reason for withdrawing from the joint Navy-Army *Jupiter* project that the liquid propelled *Jupiter* just wasn't suitable for shipboard operations. A 2000-mile ballistic missile such as *Big "B"* would have greater range than the first-planned models of the Navy's Fleet Ballistic Missile, *Polaris*. First models of this are to have the conventional IRBM range of 1500 nautical miles.

It may well have been the engine for this that a Thiokol spokesman was referring to a short time back when he indicated that his company was working on a solid-propellant motor with a thrust of over 300,000 pounds.

One thing seems certain. If a solid-propellant missile of this nature is forthcoming within the next year it will certainly raise serious doubts as to the feasibility of going into heavy production on the operationally less flexible liquid-propelled *Jupiter* and *Thor*.

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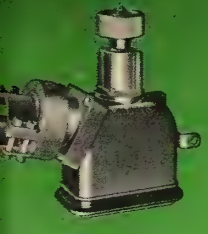
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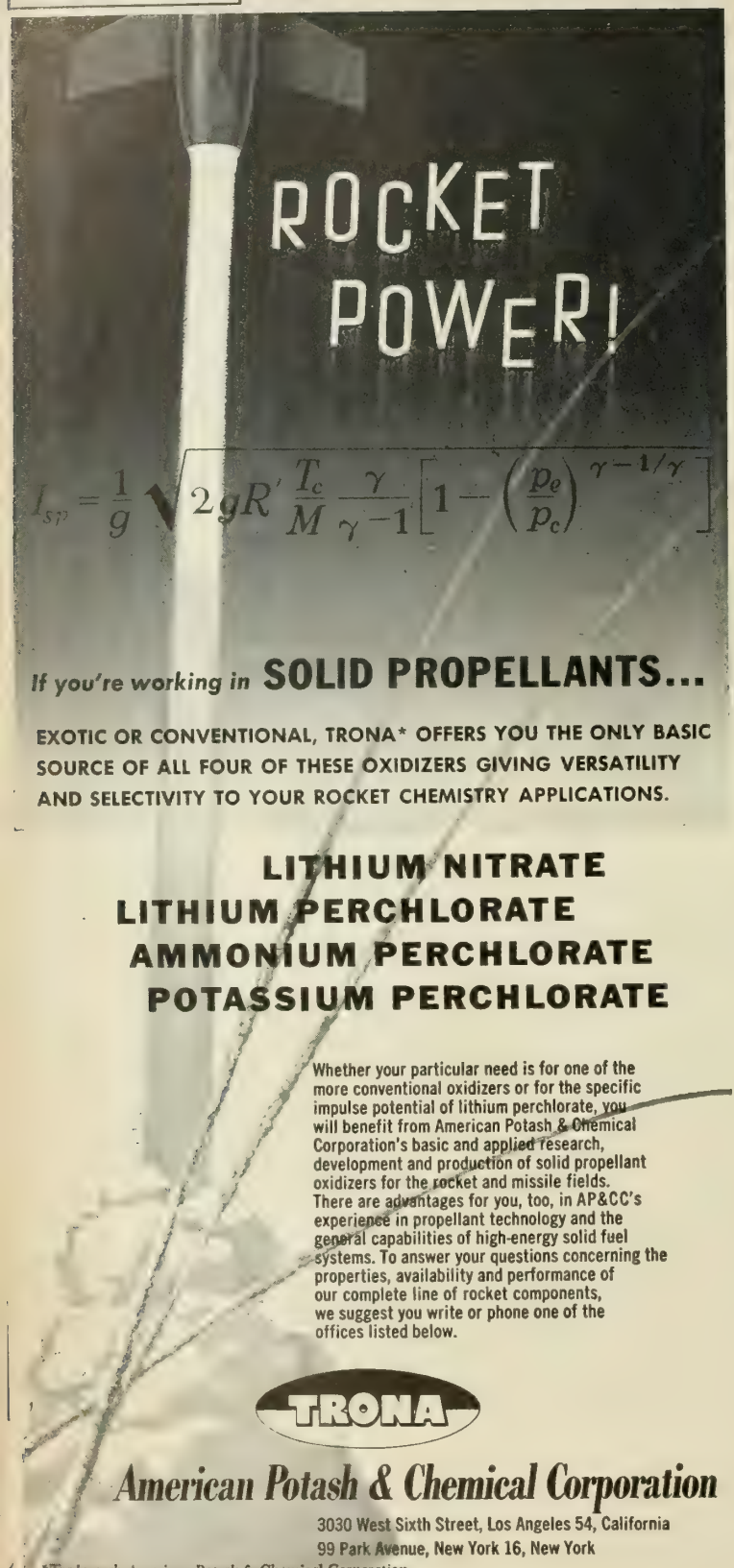
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Cislunar Aspects Checked at ARS Meeting

Utilities to be derived from cislunar operations were described by Krafft A. Ehricke, assistant to the technical director of Convair-Astronautics, in a space flight paper presented before the semi-annual meeting of the American Rocket Society in San Francisco.

These pertain to terrestrial observation, terrestrial communication, arrival from Venus or Mars, interplanetary communication and tracking by obtaining adequate baselines and to cislunar as well as lunar research. Even a vast television show—receivable on home sets—is a prospect.

The three-day gathering was held under the auspices of the northern California section of ARS in conjunction with the 1957 semi-annual meeting of the American Society of Mechanical Engineers, and the dual program attracted a large attendance. Feature events included a dinner at which Rear Adm. W. F. Raborn, director of the special projects office of the Bureau of Ordnance, was the speaker and a luncheon addressed by Dan A. Kimball, president of Aerojet-General Corp.

Missiles will continue to be a subordinate weapon for aircraft carrier task groups during the next 10 to 15 years, Adm. Raborn declared in his talk. Both air-breathing guided missiles and long-range ballistic missiles can play important supporting roles, he said. They can "shock" and largely neutralize the enemy air defenses in any kind of weather, and thus open the way for the attack by carrier-based manned aircraft, he declared.

Aerojet-General hopes to get underwater rockets up to speeds of 300 to 400 mph, with extended range, Kimball reported. He also assured his listeners that "real good progress" is being made on intercontinental missiles.

The effect of lunisolar perturbations on high observational and communications satellites, likely to be located from 3 to 10 Earth radii out, is very small and may be disregarded for most purposes. In the same region, terrestrial perturbation due to the Earth's asphericity is greatly reduced compared to the effect on low-altitude orbits. This transition zone, where the amount of perturbation from either source is particularly small, Ehricke calls a "zone of quiet." In this zone near-circulatory orbits are particularly stable.

If chemical space vehicles are to be used for manned interplanetary mis-

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sions, Ehricke propounds the advantages of a captured satellite orbit at about 15 Earth radii out for the return trip from Venus or Mars. Less energy would be required than at closer distance from the Earth. The space craft would remain occupied only for a comparatively brief period of time.

As soon as their final orbit is accurately known on the ground, a relief vehicle would be sent up to transport the interplanetary crew down to earth. Ehricke points out that for vehicles with very high specific impulse, such as ion-powered vehicles and perhaps others, such complications would not be needed.

Farther out in cislunar space, lunisolar perturbation increases, but even at 20 Earth radii is not prohibitive for transponder satellites of what Ehricke calls a "terraluna antenna system" for interplanetary tracking and communication.

Thiokol's Utah Test Facilities Operating

Static test facilities at Thiokol Chemical Corp.'s new Utah Division are operating. Production facilities at the location are slated for completion in the fall.

Five-Stage Rocket Proposed By Truax

The increased use of rocket power plants with as many as five stages may require a look at some fields that were passed over.

Navy Commander Robert C. Truax, president of the American Rocket Society, and currently on special duty with the Ballistic Missile Division of ARDC, told members of the First Helium Symposium sponsored by the Aeronautical Division of Robertshaw-Fulton Controls Co., Anaheim, Calif., that "we cannot continue leaning blindly on tradition."

"We need a new kind of rocket for successful multi-stage rocket development, and we may be required to stop the chain of evolutionary development and take a different tangent," Truax declared.

Latter stages of a rocket power plant are subject to environmental conditions considerably different from those of the initial stages, such as a lack of back pressure, the direction of the gravity vector and the accompanying effect on performance. It was suggested that a re-examination and re-evaluation of optimum chamber philosophies may be the key to simpler and lighter latter stage design.

One suggested solution was a reduction of chamber pressures from what is currently considered optimum for overall rocket design. By reducing these pressures two major gains could be made: a savings in weight and a reduction in heat flux densities.

The reduction of heat flux density requires lighter and simpler construction, permitting use of thinner materials and the possibility of adapting modern welding techniques for ease of fabrication. It may also be possible to eliminate the turbo-pump entirely by using a pressure-fed system and chamber pressures on the order of two atmospheres absolute.

Lower feed pressures will reduce thrust and, as the flow rate decreases, the bulk coolant temperature will rise and tend to boil. Although this has been considered a somewhat undesirable condition, it may be allowable if chamber pressures go down.

"There is no data available to



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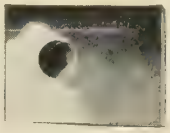
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show we can't, and some recent data shows we can," said Commander Truax.

Described as wet steam, the product of bulk boiling might be difficult to meter and may create a problem in control of mixture ratios, but as it may also flash into vapor during downstream flow, the possibility of utilizing atomization in place of impingement velocity should be considered.

The reduced thrust which would result in a latter stage rocket designed around the possibility of lower chamber pressures, plus the gravity loss increases, would become less important and might be resolved by extending the burning time. If the vehicle can be made smaller, the thrust/weight ratio may become unimportant.

In conclusion, Truax suggested that a program of research and development in boiling heat transfer is needed. He again stressed a scrutiny of optimum chamber pressure valves as an approach to the simplification and weight reduction of latter stage rockets.

Another speaker, William H. Lawrence, chief of the Mechanical Section at Edwards Rocket Base, Calif., told symposium members that "the rocket industry will grow to a large extent on the adequacy of gas component design."

Discussing the subject of "Operational Helium," Lawrence declared that a re-evaluation of philosophy of system operation is seriously needed.

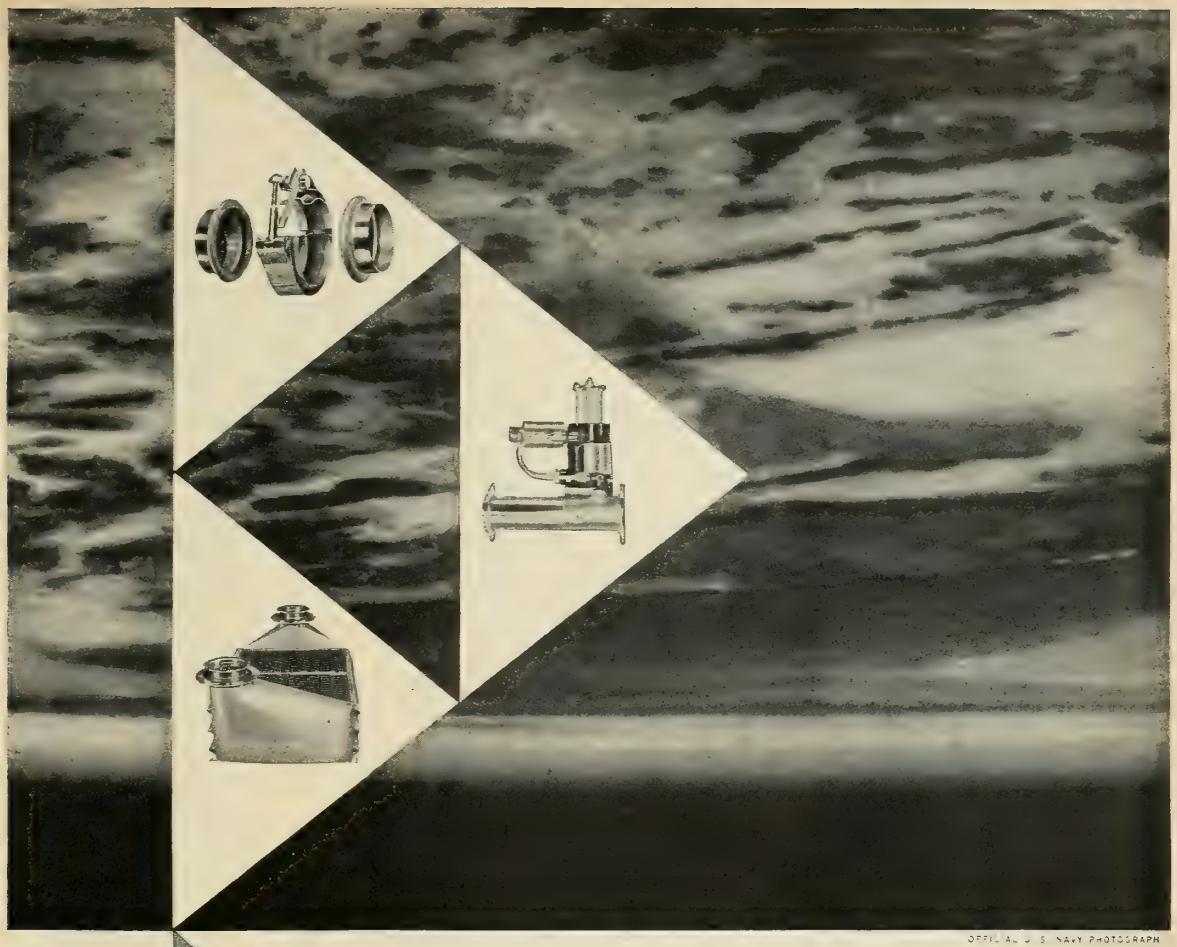
He pointed out an apparent lack of suitable high-pressure relief valves as existing components "either leak or start seeping several hundred pounds prior to relieving," and described the use of burst diaphragms at the Edwards Facility to prevent this.

Lawrence predicted an increase also in the use of liquid helium because of advantages in transporting, storing, and pumping which enable a large-scale user to handle a moderate quantity of the liquid and "do the same job which now requires an all-out effort with 'railcars' of K-bottles."

Firebee Achieves 14-Flight Record

Ryan *Firebee* "Drone 1518" has been parachute recovered 14 times in the desert at Holloman Air Development Center, N. Mex.

The drone, according to Holoman officers, has averaged more than 40 minutes per flight since it went into service Jan. 9, 1956, and has streaked at high subsonic speeds for more than an hour on three of its flights.



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"As a graduate engineer or scientist with an aptitude for creative thinking, your future is with CONVAIR-*ASTRONAUTICS*. Here you will associate with the leaders in this advanced field – work in our new $40,000,000 facility. You will see and feel the kind of achievement that means personal progress. And you will enjoy living at its best in beautiful, smog-free San Diego.

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New ICBM Data Telemetry Process

ICBM nose cone data acquired from flight tests are being fed back to General Electric Co.'s engineers 300 times faster than previously possible.

A unique automatic data processing facility installed at the GE Missile and Ordnance Systems department in Philadelphia has just been installed as an aid in the technological race to perfect the ICBM nose cone.

Harry Rosen, manager of the facility, said schedules calling for a maximum of 3-4 days to process 300 types of information telemetered back from a typical nose cone test could not be met by usual data handling methods.

An IBM 704 machine was chosen together with automatic analog and digital conversion machines and switching equipment to do the job. Many of the machines were designed by GE for the purpose.

Tapes containing information from nose cone tests run by various government and industrial organizations is sent to GE. Computations and graphical reports are then made up in record time for GE's 1100 engineers and scientists employed by the Missiles and Ordnance Department.

Autonetics Boosts Film Production

Autonetics division of North American has established a separate motion pictures unit and Jay E. Gordon, formerly supervisor of the motion pictures unit for both the Autonetics and Missile Development divisions has been named supervisor of the unit. He is assisted by Walter V. Hardy, in charge of professional and administrative services, and John D. Rogers, who heads the unit's production and technical services.

Autonetics has more than 30 motion pictures currently scheduled for production this year.

m/r Gets New Editor To Cover Red Missiles

Under its editorial expansion program, m/r is pleased to announce the addition of Dr. Albert Parry to its staff of contributing editors. Dr. Parry is Head of the Department of Russian Studies, Colgate University, Hamilton, N. Y. He will provide m/r readers with constant coverage of missile developments behind the Iron Curtain. Dr. Parry will have a regular column, Behind the Curtain (see page 67), as well as periodic feature and news stories.



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U.S. Army is Confident of Future ABMA Role

HUNTSVILLE, Ala.—With the Air Force assuming financial responsibility on July 1st for a considerable part of work on the IRBM at the Army Ballistic Missile Agency here, the Army itself is smarting more from what it considers "blows to its prestige" than from fear of any appreciable cutback in funds or manpower for continued research and development of missiles and rockets of every variety and range.

Most of the top officials concerned, m/r found, were little disturbed by the furor that has resulted from the dispute over the Air Force *Thor* and the Army *Jupiter*, both IRBMs.

That battle is still on and now the Army has challenged the Navy over who can make and fire the best earth satellite. Published reports indicate that to date four *Jupiters* and three *Thors* have been launched. All the *Thors* are reported to have failed. Two of the *Jupiters* are said to have achieved remarkable results, one reaching a distance of 1,650 miles.

The Army has been extremely agile in announcing the results of the *Jupiter* tests. The Air Force has said little or nothing about the *Thor* except that the missile has a "production configuration," presumably with fins.

A fifth *Jupiter* may have been fired by the time this article is in print. The most successful Army missile to date is supposed to be the *Jupiter "C"*. This alphabetical designation, however, does not mean that it was the third to be launched, and this missile is actually a *Redstone* with two additional solid-propellant stage rockets.

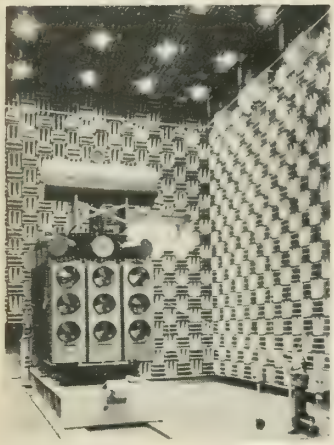
If anything, the importance of the Army's role and mission has increased with the development of missiles. It is more powerful and more mobile than ever before in its history. Even with its operational control of missiles limited to those with ranges of 200 miles or less, its zone of operations on a battlefield has been greatly extended over the relatively narrow strips that were its responsibility as forward zones in World War II and Korea.

The *Jupiter* is only one of "between 30 and 50 projects" now under way at Redstone Arsenal and ABMA. These projects are being conducted for and in co-operation with the Army, Navy, Air Force and Marines. Many of them are already programmed for as long as 1962.

Informed estimates on the amount of money still available to Redstone and ABMA from the appropriations of recent years—funds authorized but not expended from as far back as fiscal 1950—are as much as $750 million.

Some of it would have been earmarked for work at other arsenals and by private industry, but the ultimate control would remain with Redstone and ABMA. This is in addition to the funds that Redstone and ABMA will receive for missile and rocket projects from the Army's fiscal 1958 appropriation of about nine billions.

On top of this is the obvious effect on the Army and its contractors of the recent decision to equip NATO allies with missiles. If the established pattern of military aid to Europe is followed, the Army will be asked first to train and equip NATO units with some of the earlier missiles such as the *Corporal*, *Honest John* and *Nike*, plus smaller ones such as the anti-tank *Dart*, a little five-footer.



Anechoic Chamber in World's Largest Sound Laboratory, General Electric Company, Pittsfield, Massachusetts. AN-ECK-OIC® wedges, Radiation Shielding and Spring Tension cable floor fabricated and erected by THE ECKEL CORPORATION, Cambridge, Massachusetts.

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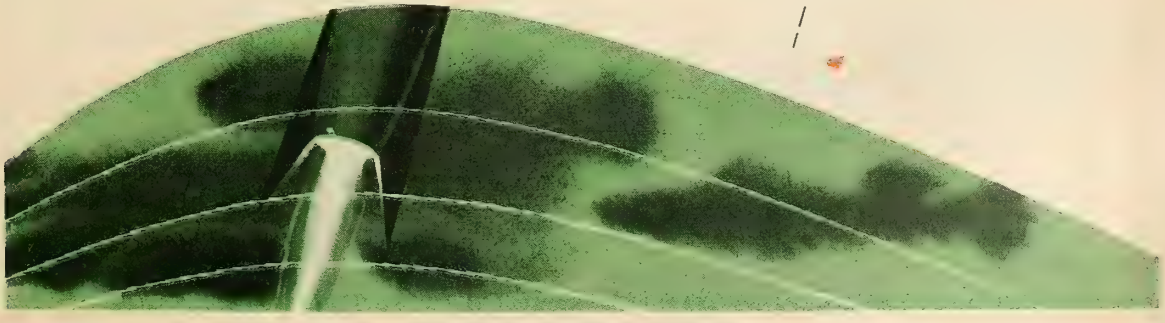
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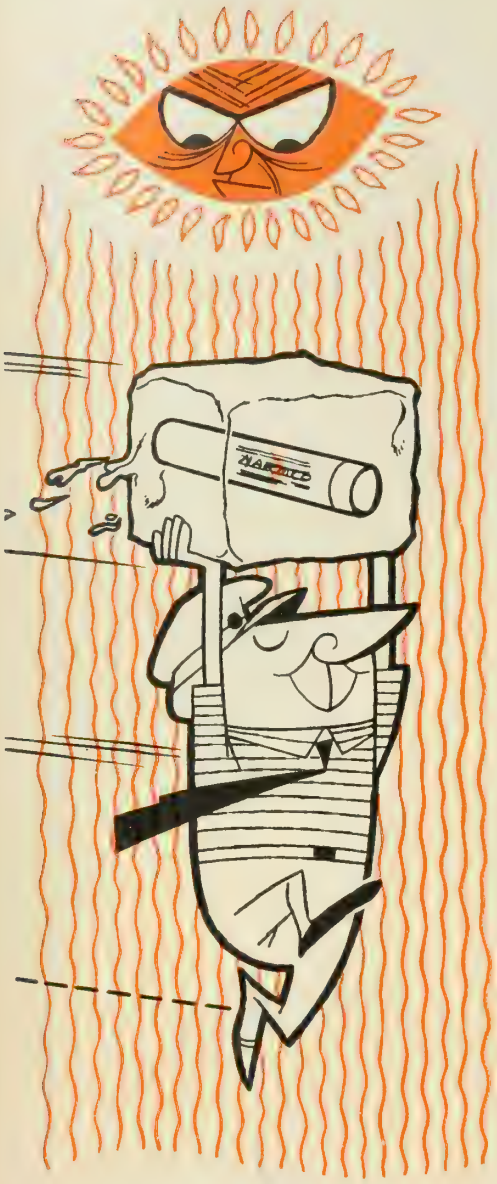
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Floating Telemetry Bases for AF Test Range

Floating telemetry bases will be used to fill the gap that now exists in the Air Force's missile test range between St. Lucia and Ascension.

Six Liberty ships have been demothballed at Oakland, Calif. and telemetering equipment has been installed by the Ralph M. Parsons Co., Pasadena, Calif. Operation of the fleet will be under direction of the Guided Missiles Range Division, Pan American World Airways. Operation will begin later this year.

Electronic equipment on board will be operated by the Radio Corporation of America, subcontractor to Pan American. A special area in the ships is designed to provide controlled ambient atmospheric conditions to insure accuracy of recorded data acquired by helical telemetry antennas mounted on the bridge of each ship. Data will be transmitted from the ships to Cape Canaveral, Fla. where the AF range control station is located.

The ships will be capable of operation for three week periods before returning to their bases in South America. The work of the "ocean range vessels," as they are called, will be supplemented in 1958 by five larger vessels that will be used to record missile impact data.

Temco Predicts Sales of $127 Million

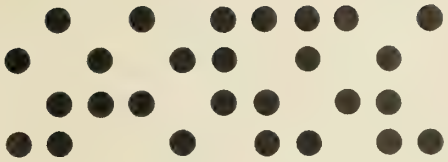
Temco Aircraft Corp.'s president Robert McCullough has predicted that his company will do $127 million in business this year, compared to $90 million in 1956.

He said that the company's Garland plant will have 3,000 employees by early 1958. Its payroll will reach $7.5 million this year, compared to a little over $6 million last year. McCullough hinted that Temco's operation in Grand Prairie eventually may be moved to Garland where the company is building a $2 million engineering and office building on its 400-acre site.

The Garland plant is working on the Navy *Corvus* missile.

A. C. Sparkplug Gets Missile Facility Funds

A. C. Sparkplug Division of General Motors has received a $3,340,000 contract from Air Materiel Command for ballistic missile facilities. The company is working on guidance for *Thor* IRBM.



COMPUTERS

If you are an experienced computing analyst—or if computing and data reduction are new to you but you are a qualified engineer—there is interesting work as well as a bright future for you in Northrop Aircraft's growing Computer Center at Hawthorne, California.

Applied mathematicians and engineers are needed as computing analysts for assignment to Northrop's analogue computing facility, as well as the newly expanded digital electronic computer department which provides unparalleled service in the practical solution of complex engineering problems.

Northrop has many openings on its other projects having to do with jet aircraft and missile design. They include positions for electronics and electro-mechanical engineers and lab technicians. In addition to attractive compensation, Northrop offers benefits unexcelled in the airframe industry as well as helpful cooperation by forefront engineers for your professional advancement.

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If you qualify for any phase of computer research, design or application, we invite you to contact the Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., ORegon 8-9111, Extension 1893, or write to: 1015 East Broadway, Department 4600- L, Hawthorne, California.



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New Way to Make Titanium Tetrachloride

Scientists at Armour Research Foundation of Illinois Institute of Technology have developed a way to make titanium tetrachloride at temperatures much lower than required for the present method—with a higher purity and at less cost.

The compound is necessary in the manufacture of titanium.

The new process opens the way for use of low grade ores, such as ilmenite, in titanium manufacture, according to Clark E. Thorp, manager of the Foundation's chemistry and chemical engineering department.

The process starts with a "cold chlorination" of ilmenite ore at freezing temperatures, where the conventional process requires very high temperatures to chlorinate a high grade ore (rutile).

Key reaction is the precipitation of potassium chlorotitanate from ilmenite solution and the decomposition of the precipitate into titanium tetrachloride and potassium chloride at candle flame temperatures.

Thorp said it will take some time to develop the process fully. Patents have been applied for, and the Foundation is offering the process to industrial sponsors for further development.

Aerojet-General Has Private Stock Sale

Private placement of 33,500 shares at $225 per share of common stock of Aerojet-General Corp. and promise of a 10-to-1 split before year's end has been announced by William O'Neil, president of General Tire & Rubber Co., chief stockholder.

The sale was negotiated by Kidder, Peabody & Co., Inc., and Auchincloss, Parker and Redpath, and leaves General Tire's ownership at 87.6%. Proceeds will be added to working capital.

O'Neil said the placement agreement included assurance that General Tire would not consent to conversion of outstanding Aerojet-General preferred into common stock and that General Tire would vote for a split in Aerojet-General's common on at least a 10-1 basis within a year.

Aerojet Gets Contract for Engines, JATO's

Aerojet-General has received a $1,948,924 contract for 1.8KS-7800 rocket engines and $723,232 for JATO's and igniters, according to the Department of Commerce.



"ECLIPSE" a recent painting by Simpson-Middleman, gifted artistic interpreters of the physical sciences. About this new expression they write: "'Eclipse' was painted as a result of watching an actual eclipse of the sun. We were particularly struck with the curious light that was both dim and glowing and the unusual pattern of the shadows on the leaves of the trees around us. We had never seen anything like it before." Painting courtesy of John Heller Gallery, Inc.

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BOEING

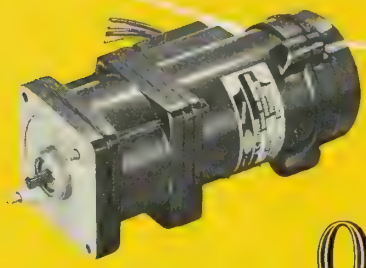
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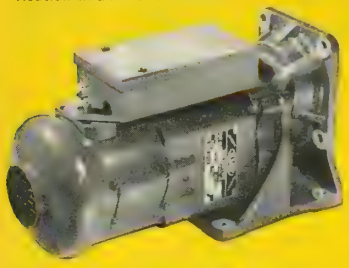


Type: C-1874 400 cycle 3 phase AC Motor and Clutch. **Weight:** 4.5 lbs. **Voltage:** 200 volts. **Output:** 650 watts. **Intermittent duty:** 12,000 rpm. **Meets Military Specification** MIL-M-7969A (ASG).



Type: D-638 400 cycle AC Motor. **Weight:** 17.5 lbs. **Voltage:** 200 AC, 20 amps at 6.5 hp. **Duty cycle:** 3.0 seconds at 6.5 hp, 15.0 seconds at 1.5 hp. **Maximum capacity:** 6.5 hp. **Continuous rating:** 5 hp at 2300 rpm, 15.8 amps, 200 volts. **Meets Military Spec.** MIL-M-7969A (ASG).

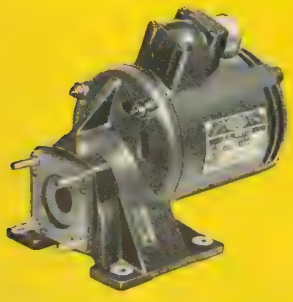
Over the years the precision, ruggedness and reliability of EEMCO products has been proven time and time again. The consistent, exceptional performance of these low-weight, high-output motors, a few of which are illustrated, has earned EEMCO industry-wide recognition. In this highly specialized field, where perfection is imperative, the widespread use of EEMCO motors and of EEMCO's equally reliable actuators is eloquent testimony.



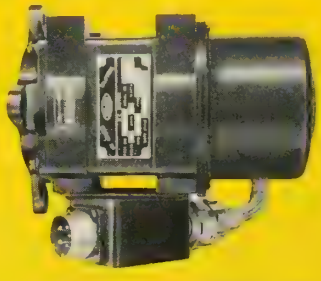
Type: D-751 DC Motor. **Weight:** 20 lbs. **Duty Cycle:** 5.2 hp at 2100 rpm (intermittent) on 26 volts DC; 3.5 hp at 2200 rpm (continuous) on 26 volts DC. **Meets Military Specification** MIL-M-8609.



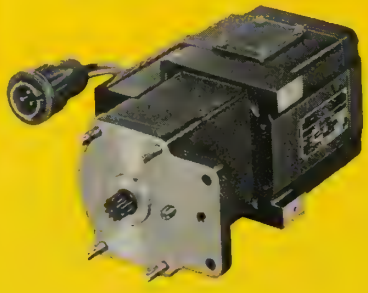
Type: D-800 400 cycle 3 phase AC Motor. **Weight:** 8.75 lbs. **Voltage:** 208 volts. **Horsepower:** 2.5 hp. **Continuous Duty:** 11,300 rpm; Equipped with thermal protector. **Meets Military Specification** MIL-M-7969A (ASG).



Type: D-899 400 cycle 3 phase AC Motor. **Weight:** 11.25 lbs. **Volts:** 200 volts. **Load:** 2.75 hp continuous output. **RPM:** 3140 rpm output at gear box. **Power factor:** 83%. **Overall efficiency:** 76% for entire unit. **Meets Military Specification** MIL-M-7969A (ASG).



Type: D-932 DC Motor. **Weight:** With radio noise filter—13 lbs., without same—12.4 lbs. **Terminal voltage:** 27.5 DC plus or minus 1.5 volts. **Load:** From .5 hp minimum to 2.6 hp maximum. **Speed:** Continuous at 12,000 rpm, plus or minus .005%. **Speed Control:** By frequency regulator supplying control field. **Meets Military Specification** MIL-M-8609 (ASG).



Type: D-927 DC Motor. **Weight:** 7.25 lbs. with 2-circuit noise filter for ungrounded systems. **Weight of filter:** 1 lb. **Terminal voltage:** 27 volts, 18 amps. **Load:** 0.5 hp. **Speed:** Continuous at 9900 rpm. **Meets Military Specification** MIL-8609.

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INTERNATIONAL NEWS

By Anthony Vandyk

Bloodhound is Mainstay of British Air Defense

New details have been released about the Bristol/Ferranti *Bloodhound* surface-to-air missile system. *Bloodhound* will be the mainstay of the automatic system which will progressively take over the defense of the UK from the manned fighters.

Bloodhound is a semi-active homing missile (guided by a radar beam projected at the target, and reflected back to receiving equipment in the missile itself). As a hostile aircraft approaches, its position is plotted and followed by radars. Coordinates of this position are fed automatically to a second ground radar unit and the missile launchers move automatically to bear on the target. As soon as the echo from the target indicates by its strength that the target is within range, a green light flashes in front of the launch controller who has only to press the firing button to send *Bloodhound* roaring into the sky. From that moment the hostile aircraft has failed in its mission—no amount of evasive action by the target can shake *Bloodhound* off the scent, Bristol states.

Reflections of the illuminating radar beam from the target are received by *Bloodhound*. In this way, the target illuminating beam enables the missile to "see" the target in much the same way as a searchlight would enable it to be seen by the eye. During flight, the missile senses the direction from which the illuminating beam is being reflected and automatically turns towards the position of the target. Any evasive action the target may make is automatically followed and appropriate signals from the guidance received to the missile control surfaces continuously correct the heading of *Bloodhound* relative to the target.

The *Seaslug*, the first guided surface-to-air missile for the Royal Navy, is a medium-range weapon, it has been officially announced in England. It is a rocket-propellant missile, with rectangular cruciform wings and tail guidance blades, launched by four wrap-around solid propellant boosters mounted on the forebody. Triple launching ramps, with automatic loading from magazines below decks, are used so that personnel are not exposed.

Targets are initially detected and tracked by long-range radar. Feed-in of target range, bearing, height and speed information is computed to position launching ramp and indicate firing time. The system is fully compensated for ship's roll. The missile apparently has fully active homing.

Firings of the *Seaslug* have taken place at Woomera, Australia and at Aberporth, Wales, from the Clausen rolling platform which simulates a ship's motion. Since July 1956 sea firing programs have been undertaken in HMS Girdle Ness, the Royal Navy's first all-missile ship.

While the missile designed was coordinated by Sir W. G. Armstrong Whitworth Aircraft, the launching ramp, magazine gear, radar and associated weapon direction and control equipment were developed by the Navy. Contractors "intimately connected" with the weapon system were: the General Electric Co. Ltd. (guidance), Sperry Gyroscope Co. Ltd. (autopilot), John Thompson Conveyor Co. Ltd., Sir George Godfrey and Partners, Vickers-Armstrongs Ltd., Metropolitan Vickers Ltd., McMichael Radio Ltd., E.M.I. Engineering Development Ltd., and Imperial Chemical Industries.

Japan Shows Interest in Satellite Tracking

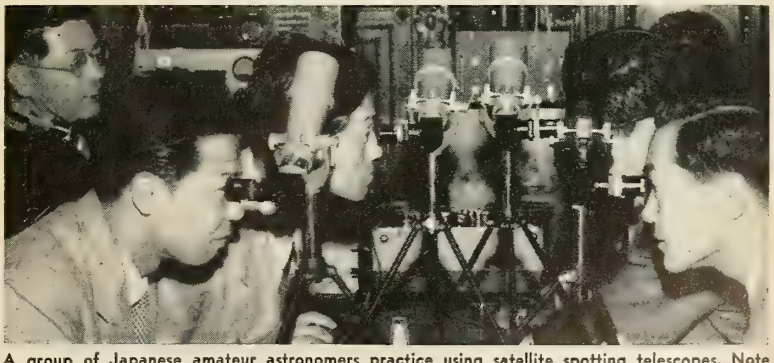
Japan seems more enthusiastic and excited by the forthcoming satellite launchings than any other nation, not excluding the U.S.

Japanese interest in rockets and astronautics was described in this magazine earlier (October and November, 1956). But the desire to participate in the U.S. satellite tracking program is greater than that shown by any other nations within the 40° North and South parallels. The extent of this popular interest is shown by the number of volunteer satellite observing teams.

Dr. Masai Miyadji, Director of the University of Tokyo Observatory, was picked by the Japanese National Committee, IGY, as coordinator for satellite tracking. This action was taken last October by the Japanese Science Council following the CSAGI meeting at Barcelona. Miyadji, an astronomer, is currently completing a six-week visit to the Smithsonian Astrophysical Observatory at Cambridge, Mass., center of optical tracking programs.

Dr. Miyadji's particular specialty is "time and space." While in the U.S. he will study optical and radio tracking.

A modified Schmidt camera, crys-



A group of Japanese amateur astronomers practice using satellite spotting telescopes. Note individual time signal keys, radio time signal receiver, and tape recorder. In background, not shown, is projection screen for use in simulating satellite motion of 1/5 to 1 degree per second. Students are members of Japanese Astronomical Study Association and are training for Japanese Moonwatch program. Photo was taken at the Science Museum in Tokyo.

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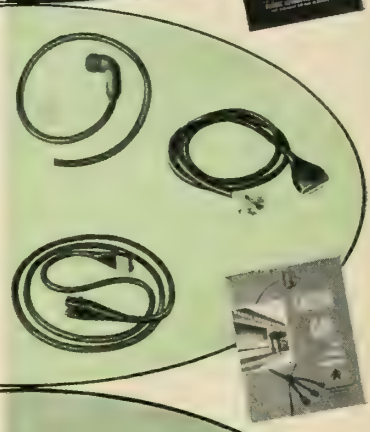
CABLE SPECIFICATIONS

"Design Engineering Specification" Bulletin No. PAP-C-101. Comprehensive 19-page engineering manual describing materials, construction, design criteria, specification conformance, performance, identification, documentation and other important features determining correct cable for your specific application.



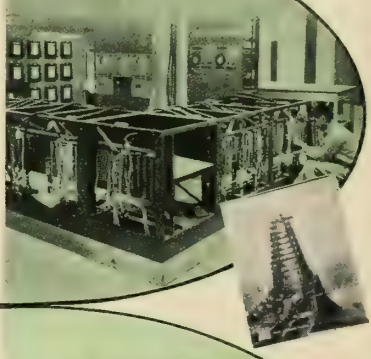
CABLE AS A COMPONENT

"Electronic Cable as a Systems Component" Bulletin No. 656. Generously illustrated pamphlet describes design and production of electronic cable in bulk and assemblies. Connectors and hardware; cable break-outs; environmental requirements; voltage rating, testing; cable procurement data – are some of the subjects covered in this bulletin.



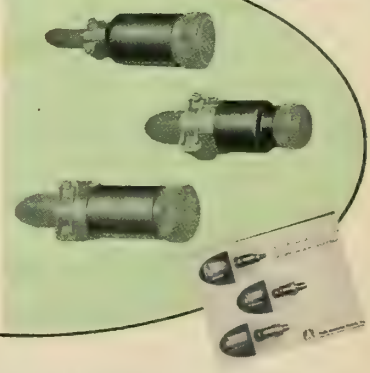
CABLE SYSTEMS

"Engineered Cable Systems" Bulletin 357. Illustrated brochure describing Pacific Automation Products' pioneering in the use of the Systems Concept to coordinate cable design with the development of complex electronic systems. Liaison engineering teams cooperating with systems design groups establish cable as integral part of system, supervising cable construction concurrently with development of other elements.



CABLE ACCESSORIES

"Extension and Adapter Sleeves for Cable/Connector Compatibility" Bulletin 257. Illustrated bulletin on aluminum adapters designed and manufactured by Pacific Automation Products, which for the first time provide a means of attaching any size AN connector to any size cable, with assured reliability.



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tal clock timer and associated equipment will be provided by the U.S., and installed at the Tokyo Observatory by January 1958. The station will be one of the 12 official U.S. stations. The Japanese Science Council and Tokyo University will cooperate in station management and operation.

In addition volunteer observing teams are being readied under the Moonwatch program. Twenty-five of these teams have already been officially approved and 5-10 more are in the process of organization. Dr. Miyadji is assisted by a committee of three: Professor Hirose, Mr. Torao, and Mr. Iijima, all of the Tokyo Observatory.

It was learned that the three major astronomical and two rocket societies have pledged support: Japanese Astronomical Society (Tokyo), Oriental Astronomical Society (Kyoto), Japan Astronomical Study Association (Yokahama), Japanese Astronautical Society (Tokyo) and the Japanese Rocket Society (Tokyo).

Total membership of these societies is about 3000.

Science departments of high schools are organizing observing teams under the leadership of Mitsuo Harada, science writer and president of the Japanese Astronautical Society. Whether or not these teams receive accreditation as official observers, they will be encouraged by the Science Council because of the scientific interest and training of students which will result. Each team is headed by a responsible accredited astronomer.

Three major newspaper chains, Yomiuri Press, Asahi Press and Mainichi Press, have agreed to pick up the tab for spotting equipment needs. A Japanese optical firm has designed high-quality monocular 'scopes at a cost of about $40 each.

Sweden to Employ Anti-Tank Missile

Sweden's Guided Weapons Bureau now has a staff of about 250, General C. A. Ehrensvard, Commanding General of the Swedish Army, has disclosed. Discussing details of the Army's guided weapons procurement program, he said that nuclear weapons supplement other weapons but do not replace them. The first missile to be introduced on a large scale among the Swedish defense forces will be an anti-tank missile.

This is likely to be the French wire-guided *Nord* missile in its improved SS-11 version. If tests with the missile are successful the Army will acquire the *Nord* SS-11 in sufficent quantities for its war organization.

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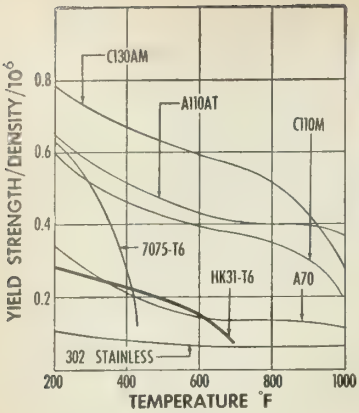
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World Astronautics

By Frederick C. Durant III

Arrangements may now be made for attendance at the Eighth Annual Congress of the International Astronautical Federation (IAF). The meetings will be held at Barcelona, Spain, October 7-12. The Spanish host society is the Agrupacion Astronautica Espanola.

The Thomas Cook & Sons tourist agency has been designated as official agent for hotel reservations for the congress. Block bookings in all classes of Barcelona hotels have been made. Check with the nearest office of Thomas Cook & Sons which has branches in all major U.S. cities, or with the Barcelona office, address:

Wagon Lits Cook, Paseo de Garcia, 8-10, Barcelona, Spain.

All meetings will be held at The National Center for Scientific Research, Barcelona, with one exception; the initial meeting of the IAF Council on Sunday, 6 October.

•

A. V. Cleaver, British rocket expert of Rolls Royce, Ltd., has authored an interesting two-part article in "Flight" recently. Cleaver, a past chairman of The British Interplanetary Society, compares the predictions of early aircraft builders and scientists (circa 1900-1930) concerning future developments in aviation. They underestimated by a wide margin the rate of advance and extent of future aeronautical progress.

Cleaver draws an interesting parallel between the progress in rocket technology of today and realization of space flight tomorrow. One error made by the pundits of a few decades ago was in not recognizing the cumulative effect of many individual technical improvements upon future aircraft performance. It is possible that the same error in synergism may be made in today's predictions of the rate of achieveing manned space flight. Furthermore, the exponential rate of technological growth of the past decades may be expected to produce breakthroughs of completely new techniques and developments that are today unidentified. The import: astronautical developments possibly much sooner and on a greater scale than now anticipated.

•

A symposium on "High Altitude and Satellite Rockets" to be held 18-20 July at Cranfield, England, is being organized jointly by The British Interplanetary Society, Royal Aeronautical Society and the College of Aeronautics. This top-level meeting and exhibition is the first such affair to be held in Great Britain. The program resembles the pattern of the week-long course, in "Orbital Vehicles and Satellite Flight" held at MIT last summer.

•

Nearly 200,000 visitors were attracted to the U.S. rocket exhibition in Frankfurt recently. A similarly large attendance occurred at Stuttgart. Entitled "Space Unlimited" these shows stress the peaceful application of rocket power. Much good will has resulted. A film, titled "Adventure in Space Flight" has been produced by the U.S. Information Service. It features unclassified films of *Aerobee, Viking, Nike* and American V-2 research. There is strong interest in more of the same. The USSR Embassy at Bonn is countering with releases of information on Russian space medical research using dogs in sounding rocket flights.



Behind the Curtain

By Dr. Albert Parry

Soviet scientists plan to use rockets in their ambitious scheme to radically change the night lighting of Soviet cities. Clouds of luminous gas in the ionosphere are to be utilized for such lighting. The procedure will be as follows: As twilight falls, rockets will be employed to throw into the ionosphere a catalytic agent which will cause atoms of oxygen to form into molecules. It will be in the process of this formation that the needed light will be produced for Soviet streets.

Russian savants are not saying, however, just how soon this revolutionary change in their municipal mode of life will be brought about.

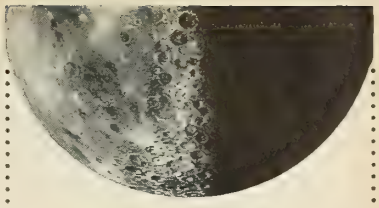
To the question, "When will the Soviets send up their first earth satellite?", Moscow replies rather vaguely: "In the next few months." But a much more exact date is the educated guess of an émigré Russian now living in the U.S. He is V. Nekrasov, an elderly artillery expert sent to this country by the tsarist government during World War I as a staff member of the tsar's commission to buy munitions for the Russian army. Interested in rocket propulsion since his young manhood, and well acquainted with the life and work of Constantin Tsiolkovsky, Russia's pioneer rocket theoretician and inventor, Nekrasov now says:

"September 17, 1957 will mark the one hundredth anniversary of Tsiolkovsky's birth. Quite some time ago the Soviet government announced that it would celebrate the date in a most fitting manner. But since that announcement not a further word has been said by Moscow's officials about the celebration. We can explain this silence by one reason only: the Soviet government is preparing to spring a surprise on the world—it will celebrate the Tsiolkovsky Centennial by firing the Soviets' artificial satellite into space on September 17 of this year."

Through its Czechoslovak Press Agency, the Prague government indignantly denies the recent reports appearing in West European newspapers, particularly those in Austria and West Germany, that the Soviet armed forces have established guided-missile launching sites on Czechoslovak territory. Declares the Czechoslovak government:

"No such bases exist in Czechoslovakia. It is obvious that the circulation of such false reports is a transparent propaganda maneuver intended to divert the attention of the public from the fact that the U.S. has for some time been equipping its military bases in the German Federal Republic with atomic weapons with the approval of the West German Government, and at the present time the Government of the German Federal Republic is rapidly moving towards the equipment of its forces with atomic weapons. Inventions of this type cannot, however, either hide the actual preparations for atomic war on the territory of West Germany or disperse the fears of the German people of the catastrophic results of such a policy, which were so emphatically expressed recently by leading West German atomic scientists."

The Red verbiage aside, this official Prague statement shows clearly that the Czech Communists and their Soviet Russian bosses are sufficiently worried by the reports of their East European guided-missile launching sites to take this trouble of denying the reports.



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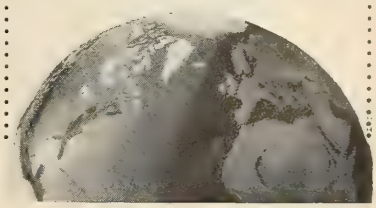
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Photonic Propulsion Discussed By Reds

In *Komsomolskaya Pravda* for June 9, Moscow's Professor K. P. Stanyukovich discusses the "photonic rocket, the mightiest theoretically possible jet motor." He writes:

"You know that in most recent years scientists have discovered the existence of so-called anti-particles, that is to say 'matters in reverse.' They have succeeded in creating some of these artificially.

"Right after being 'born,' having existed but a most insignificant portion of a second, they immediately vanish. They vanish when they run into a particle analogous to themselves. But a tremendous amount of energy comes out of this, hundreds of times more than even at a hydrogen-helium nuclear reaction.

"It is quite possible to imagine that this emergence of energy would come not as an explosion but as a relatively stable process.

"It is probable that, as a basis of an interplanetary ship, man will then use one of the satellites of either Saturn or Jupiter, or perhaps some or other large asteroid. Man will bring to it the needed quantity of anti-matters, will install there a gigantic motor, and one beautiful day this celestial body will leave its age-old path in the solar system and will hurl itself into the black abyss of the Universe.

"Of course, both the 'combustion chambers' and the 'jet' of this motor will not at all resemble what we know today of motors. Most likely these will be annular magnetic fields which will organize streams of matter and of photons. The jet stream, or more exactly the jet ray of the interplanetary ship, will be of such intensity that even at a distance of millions of kilometers it will burn everything living—in case this ray falls upon the earth. Precisely for this reason, man will place the cosmodrome for this interplanetary flight so far away from the earth.

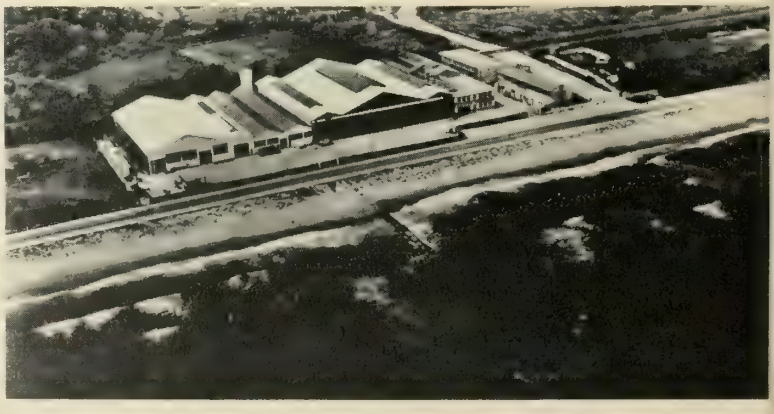
"Should it 'burn' in its motor 90 per cent of its mass, or the first stage of the rocket, so to say, our ship will fly from 250 to 280 thousand kilometers per second. Therefore, most likely, man on the earth will lose all touch with this interplanetary reconnoiterer.

"Some 10 or 15 years will pass, and then, in the black abysses of Cosmos, a star will emerge, coming toward us with a fantastic speed. It will shine forth with its ray of energetics, facing the solar system, as if it were the ray of a searchlight. The first navigators of stars will thus turn their photonic motor on, in order to brake their flight.

Professor Stanyukovich concludes by admitting that even the twenty-first century may not see this dream come true. But he insists that scientifically all this is quite plausible.

RCAF Orders *Firebees* For Training Troops

Ryan Aeronautical Co.'s *Firebee* jet target drone will be used by the Royal Canadian Air Force for anti-aircraft training of its defense forces. Canada ordered a number of the drones following a 10-day conference recently with Ryan officials.



What a wonderful location for a missile plant! This is Sud-Aviation's missile factory at La Bocca, on the shores of the blue Mediterranean near Cannes. The plant occupies an area of 15,600 sq. yds. and has a labor force of 380. Equipment includes 160 machine tools. Main activity of the French facility is the design and construction of missiles up to the pre-production stage.

Rocket Trends

by Erik Bergaust



AIR FORCE MISSILE MEN have discovered the solid propellant trend. Reportedly the Ramo-Wooldridge organization has presented a comprehensive report on solids to ARDC's Ballistic Missile Division. Some sources say the report indicates feasibility of solid-propellant ICBMs and that Gen. Ben Schriever is interested . . . Aerojet and Thiokol representatives have hinted it is possible to build a solid-propellant moon rocket. "If we can build a solid moon rocket, we can also build a solid ICBM," one industry spokesman said.

AIR FORCE AND CONVAIR were pleased with the first *Atlas* firing. The *Atlas* design concept proved to be sound. In particular, Convair *Atlas* designers were satisfied their thin-skinned pressurized hull proved satisfactory. First firing was perfect from first moment of ground check-out and countdown. Missile took off beautifully and a maze of information was telemetered back to Patrick. Fuel feed malfunction is considered minor problem, and stepped-up *Atlas* test program is underway.

AIR MATERIEL COMMAND's Maj. Gen. Baker sees a 500% increase in the next few years in missile spending; a 100% increase in military electronics and a 50% decline for manned aircraft; 40% down for turbojet engines. AF military hardware spending to hold at $7 billion with a $600 million per year R&D account. Missiles are to go from $500 million per year to $2.8 billion; aircraft to drop from $4 billion now to less than $2 billion. Electronics up from $750 million to $1.3 billion plus . . . "Money will be flowing to industry through a much more limited number of channels . . . neither R&D nor procurement can continue to support losers . . ."

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH reports of high velocity and high temperature effects being investigated in a "variety of ways" under auspices of AFOSR's Physics Directorate. AFOSR's "Research Briefs" mentions some of the methods developed under AFOSR sponsorship, for example, light gas guns and electromagetic accelerators which drive pellets of 1 to 5 grams at velocities up to 33,000 feet per second. This work is being done at the University of Utah. Electronic accelerators being developed at Armour Research Foundation and at Utah should deliver even more reproducible results. These institutions are attempting to attain velocities approximating the cratering effects of meteoric dust particles hitting against metallic surfaces used for missiles and satellites, with velocities from 25,000 to 100,000 feet per second expected.

AIR FORCE AND ARMY MISSILE FEUD should possibly be considered in light of the fact that in Russia all medium-range and long-range missiles are under jurisdiction of the Red Army. Recently, several Soviet generals and marshals artillery have been permitted publicly to state that (in Col. Gen. Fomin's words in November, 1956) "long-range rocket weapons of intermediate and strategic types . . . constitute a form of artillery. Now artillery can be employed . . . also far beyond the limits of the tactical zone of operations of the ground forces." Col. Gen. Samsonov similarly spoke of long-range rockets as "a variant of rocket-firing guns. Thus we witness a new qualitative leap in the development of artillery."

LADIES ARE NOT PERMITTED to wear shorts in the Officers Club at Patrick AFB! Military personnel may wear civilian clothing off-duty at AFMTC installations, and although the Air Force admits "informality is the keynote to civilian clothing worn in Central Florida," ladies can't wear shorts in public places such as base exchange, commissary, bank, etc. "Base regulations should be consulted on civilian attire permitted for men and women at the Officers Club and other public places on the base," AF advices.

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Washington Spotlight

By Henry T. Simmons

The U.S. will come under increasing pressure from its NATO allies during the next few years for shipments of guided missiles in addition to manned aircraft. A top Greek Air Force general told visiting U.S. newsmen in Athens last month: "Within the next five years, we must have some surface-to-surface and surface-to-air missiles. Without these new weapons we will not have the proper power to carry out our missions."

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So far, only England has officially requested U.S. missile assistance. Other NATO nations like Greece and Turkey apparently lack fundamental information on important categories of missiles, particularly air-to-air. Neither the Greeks nor the Turks have conducted a formal study of their own missile requirements, and it is doubtful whether they can take even this first step without substantial American help.

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Practice firings of the *Matador* surface-to-surface missile at the Air Force's 200-mile missile range in the Libyan Desert are a big event for several nomadic tribes of Arabs in the area. They are alerted when the weapons land, there is an immediate race by the tribesmen to capture the junk and sell it as scrap. For some years after World War II the export of shattered tanks and other equipment was a major industry for the Libyans.

•

The Army is pondering the possible joint use of the USAF missile range in Libya for training exercises of its own units stationed in Europe. The Army now has *Honest John* and *Corporal* surface-to-surface weapons in the European theater and could profitably use the African firing range established by the Air Force. Its need for a long range will be particularly acute when *Redstone* units are assigned to Europe.

•

The Air Force has revealed some surprising personnel figures for its first guided missile wing, the *Matador*-equipped 701st Tactical Missile Wing stationed in Europe. The wing has a grand total of 2,881 officers and men who operate or support 18 *Matador* missile launchers. This is almost the number of men required by a wing of strategic bombers; it suggests that the age of push-button warfare may not be as economical in manpower as initially presumed.

•

Missile strength of the U.S. Navy's Sixth Fleet in the Mediterranean was at a low ebb in June, but will increase substantially when new fleet units arrive this month. Only missile deployed in the Fleet last month was the infra-red *Sidewinder* air-to-air missile, carried by McDonnell F3H-2N and North American FJ3-M fighters. This month the Fleet expects the carriers *Randolph* and *Franklin D. Roosevelt,* which should have all-weather F3H-2N *Demons* equipped with *Sparrow III* missiles. *Randolph* may also have a *Regulus* surface-to-surface missile capability. In addition, *Terrier* anti-aircraft missiles will return to the "Med" this month with the arrival of the cruiser *Canberra.*

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The Army will begin to ship *Nike Ajax* guided missiles to its units in Europe before the end of the year. First unit to get the weapons will be the 32nd Anti-Aircraft Artillery Brigade, transferred from England last month to positions west of the Rhine. The 32nd is now equipped with 75 mm Skysweeper and 90 mm cannons, but will be re-equipped with the *Nikes* for defense of the vast Army supply depots in the Kaiserslautern area. Later the 32nd will get the improved *Nike Hercules,* and its defense responsibility will be extended to include USAF airdromes in Europe and other key targets.



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JULY, 1957

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS



Men for Missile Engineering

By J. B. Beerer

Missile Development Div., North American Aviation, Inc.

WHENEVER A NEW scientific or engineering breakthrough occurs there invariably follows a demand for new ingenuity and resourcefulness on the part of man. Thus, in the missile business today we find ourselves looking for new kinds of engineers, technicians and scientists—many of whom don't yet exist in full measure—to solve new kinds of problems.

This demand has been with us for quite some time now, particularly in the intercontinental missile field. No one will predict relief in the foreseeable future. Instead, as the state of missile art grows, so does our need for men of broader knowledge and abilities.

One program which has contributed greatly to the overall state of missile progress in this country is the advanced intercontinental missile, the SM-64 *Navaho*. Since its research inception more than 10 years ago, the *Navaho* project has brought forward major developments in basic missile systems.

The long-term development of large, liquid propellant rocket engines under *Navaho* enables a crash development to be initiated in recent years on the engines for the complimentary intercontinental ballistic missile. However, before any of these supersonic missiles are operational—developed to the point of military usefulness and operable by the military—a substantial amount of engineering and flight test remains ahead.

The *Navaho* is this country's only supersonic air-breathing guided missile project. It differs technically from the ballistic missiles in that it involves the solution of problems peculiar to airborne vehicles—an extension of the problems which the aircraft industry has been traditionally pursuing. The ballistic missiles present a unique set of developmental problems which become very severe at the extreme velocities required for long range.

The *Navaho* program was the first major USAF program established under the management system concept where the development of the complete weapons system — including power plants, guidance and composite design was to be achieved by a single company—North American. This management responsibility extends up to complete operational capability, including personnel training and logistics.

Total weapon system responsibility qualifies the *Navaho* program as a comprehensive, convenient pattern in studying today's missile projects and their attendant problems.

The problems cover practically the entire spectrum of both engineering and science. Fortunately, in *Navaho* we are beyond the research phase. We are largely beyond the basic engineering phase and into direct engineering, fabrication and flight test.

All missile programs face the very substantial task of achieving reliability. In completely automatic systems, the realization of reliability is extremely difficult but necessary before the military services can accept a weapon system for large scale stockpiling.

This brings us to the heart of our subject. We must have well trained, experienced personnel who can take the solutions of science and transform them into military hardware upon which the security of the U.S. rests.

The principle of jet power was clearly demonstrated in 100 B.C. by Hero of Alexandria, a Greek philosopher, with his rotating Eohlipile. But it has taken centuries before man was able to engineer this principle into the powerful and reliable jet engines which power our modern fighting airplanes. Today we are able to move from scientific principle through engineering to operating hardware in a relatively short time. This is to the credit of today's special types of engineer and the management groups in which he works.

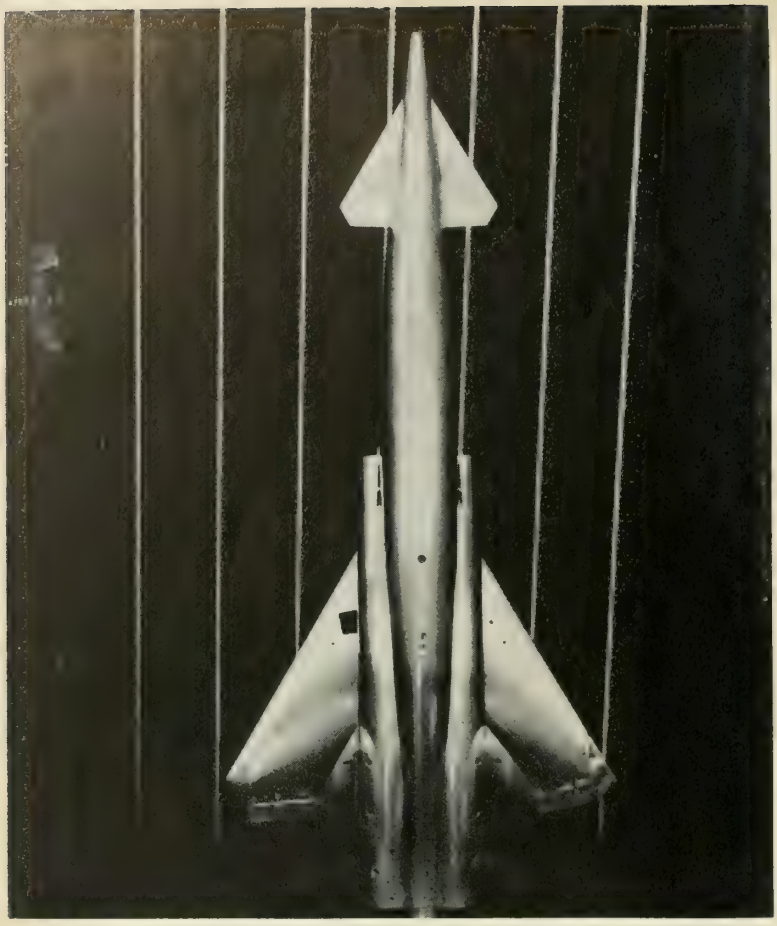
In North American's X-10, a test missile for the *Navaho*, we proved out supersonic aerodynamic design and automatic guidance and control in less time, with less effort and with fewer missiles, than we had dared hope. This reaffirms the fact that time needed to reach the hardware stage can be significantly shortened. This of course, requires vigorous and extensive system development prior to the welding together of the complete weapon system.

Engineers engaged in advanced guided missile work find that they must be closer to scientific principles than the engineer of yesterday. Looking into handbooks for approved solutions will no longer satisfy many of today's problems. The man must be capable of understanding the basic scientific principles and translating them, often directly, into drawings.

Since the systems including those pieces of equipment which we normally call "hardware" have to be designed and developed by people, people become the most important factor.

The people involved, as well as the product, are getting to be more complicated—or rather what they have to know is more complicated.

For example, we have long had an engineer we called an aerodynamicist and another we call a thermodynam-



The fine detail of this large-scale wind-tunnel model of North American Aviation's NAVAHO test vehicle, the X-10, is a good example of the knowhow needed for missiles.

icist. Now we find that at the supersonic flight speeds we are working with today sciences of aero-and-thermodynamics merge into one—and so we have the aerothermodynamics engineer.

Much has been written and spoken about the so called heat barrier—the problem of aircraft heating up to very high temperatures as they pass through the earth's atmosphere at high speeds. When we begin trying to solve these problems we find that the shape of aircraft becomes vitally important. So the thermodynamicist becomes the aerodynamicist and vice versa.

Now there is another kind of engineer who has come into being in the missile business—and I might add, also in the aircraft business. We call him a systems engineer. Our personnel people sometimes refer to him as the general practitioner of missile engineers as compared to the specialist. Perhaps it would be better to call him a multiple specialist or a man who is a specialist in several, rather than one field.

There aren't many systems engineers today. After a solid base of academic training, the systems engineer must build himself a superstructure of broad experience in the missile industry. And so we really find him pioneering a relatively new field of engineering.

However, the systems engineer must be backed up by specialists in aerodynamics, thermodynamics, hydraulics, electronics, structures, propulsion and many other interrelated specialties.

Not so many years ago, a man in aeroelasticity and flutter, for example, also had to be an expert in dynamics. Today he must spread himself into another field—electronics—for modern electronic flight simulators and computers are the tools with which he works today.

An engineer in design of automatic checkout equipment also requires quite a unique background. He devises complicated instrumentation tailored to make thousands of checks on specific missile types in preflight countdowns. To do all this he needs to know avionics, hydraulics, pneumatics and related special fields.

From every point of observation, we find the engineers and scientists growing as the horizons of the industry expand. Those who make the most significant contributions are almost always the ones who are a combination student and practical engineer.

Both industry and our schools are rising to this new engineering challenge. I know of no major aircraft manufacturer who is not spending considerable money and time for on-the-job training. These same industries are contributing to colleges to help them set up courses in such new fields—often at a graduate level—as ceramics, electronics, rocket propulsion, etc.

While our total effort in missiles today is directed toward defense and military application, the general body of scientific and engineering knowledge being accumulated will certainly find application in non-military technology.

First will come uses of new techniques and materials developed in missile research. These will include utilization of new heat-resistant materials, new methods of metal working such as chemical etching, new techniques in heat-treating, adhesive bonding and welding.

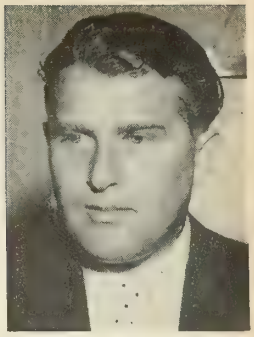
Gains in electronic growth and expansion already show themselves in computers that multiply man's computing ability a million-fold—in automation systems that operate oil wells, man machine shops and printing presses like human experts.

Sub-miniaturization shows its new importance in Tom Thumb size transistorized radio and TV sets, to name only two broad commercial applications. The field of instrumentation is rich in the applications to consumer products.

Out of the development of powerful liquid propellant rocket engines has come high speed pumps and turbines for which I'm sure many future commercial applications will be found in addition to ones we already know.

It is also significant to note that tomorrow's pilot is finding that he needs a sound engineering background if he is to meet flight challenges of the almost immediate future. While we have been designing pilotless missiles we have also been designing manned vehicles that called for new approaches. These will allow a pilot to function at new extreme altitudes and speeds. This leads us to the study of aero-medicine and human factors research.

We find ourselves faced with the need to extend the operating limitations of both men and machines. Out of this may well come new combinations of technical and engineering skills the scope of which we have only a bare indication. ★



Progress Toward Space Flight:

Space Travel and Our Technological Revolution

By Dr. Wernher von Braun

Army Ballistic Missiles Agency

DURING THE FIRST three months of this year hardly a week has passed when the newspapers did not report on some gathering of scientists and engineers who were discussing space rockets and astronautics. A few years ago that very word—astronautics —was virtually unknown, and most people bothering to stop and reflect about its meaning would at best have taken it as a mild joke.

Today one of the largest and best reputed aircraft companies in the United States has its $40-Million Astronautics Division with thousands of employees. In those astronautical meetings of scientists and engineers arguments no longer rage about the feasibility of this or that paper proposal, but about test programs, schedules, budgets, tracking organizations and rocket hardware. There can no longer be any doubt about the fact that Astronautics has reached the stage of practical engineering.

What causes this sudden interest of man in the conquest of outer space and the exploration of worlds beyond our own? As it behooves a group of astronautical hopefuls let us for a moment assume the point of view of those little green men who allegedly have been observing us for centuries from their flying saucers.

Let us see what has befallen the inhabitants of this planet earth, who after several hundred thousand years of quiet, self-sufficient earthbound existence, suddenly have learned to fly and who now, a mere 50 years later, are making visible preparations for ventures outside of the atmosphere and even beyond the gravitational field of their abode.

From their all-encompassing orbiting vantage point our little green friends would have noticed that from the beginning of the 19th Century on, strange activities set in on this planet the like of which had never before been seen. They observed how iron tracks were laid across the land.

Soon a string of coaches, pulled by a smoking and puffing something, was seen moving along the rails. Carriages, hitherto horsedrawn, were seen speeding along without the benefit of horses and humble dirt roads gave way to broad cross-country avenues which soon filled with dense traffic.

Artificial lakes appeared on the face of the earth. Wire lines supported by filigree steel towers were strung from these lakes to neighboring cities. And while these cities stayed ablaze with light after sunset, a forest of smokestacks soon began to hide them in a veil of smog.

As experienced, cosmopolitan-minded travelers through the galaxies, our visiting astronauts would have concluded that the inhabitants of this planet earth were beginning to learn how to harness the forces of nature. From their experience with other inhabited worlds, they would have known that man and his earth were in the midst of that most crucial and painful period of their existence, the transition from the pre-technological to the golden technological age.

Proud as we may be of our steady advances in the natural sciences and engineering, of all the little daily improvements here and there that we are wont to wrap up in that little word

"Technology and ethics are sisters. While technology controls the forces of nature around us, ethics controls the forces of nature within us."

It is with pride and humility that m/r reprints herewith the deliberations of a thinking man. Major General John B. Medaris, Chief, Army Ballistic Missile Agency, has described Dr. Wernher von Braun as one of the most intensely patriotic Americans alive today. He also possesses a mind that is insatiably curious, penetrating and probing. He can discuss with clarity and intelligence space flight, rockets for peace or war, the world's great religions, Europe's first industrial revolution or the motives of Tamerlane. With the new weapons described as "ultimate" and with man about to break loose from his confining earthly sphere and extend his environment to infinity, the interrelationship between God and science is no longer a subject merely for theoretical discussion but is a matter of vital practicality—a prime consideration in the struggle for survival of the species. Dr. von Braun's profound presentation was originally heard by a scant two or three hundred people at the Annual Spring Meeting of the American Rocket Society in Washington, D.C. It should be brought to the attention of everyone concerned with the affairs of mankind. Special reprints are obtainable from MISSILES AND ROCKETS *magazine.*

The Editors

"progress", we seldom stop to think how deep-reaching the effects of this technological revolution have been on virtually everything that has happened on this planet during the last 150 years.

Perhaps the fact that man's occupation with the natural sciences can be dated back many centuries, that names such as Aristotle, Copernicus and Newton are generally accepted landmarks of man's growing scientific enlightment, has somewhat obscured the picture. We should not lose sight of the fact, however, that while these and other great men searched for knowledge and truth about God's world, they did not concern themselves in the least with the application of their scientific knowledge to the plight of man.

It is an undeniable fact that only since the beginning of the 19th Century something absolutely new and unprecedented has entered human history: the determined attempt to liberate the human race from the yoke of heavy physical labor through the harnessing and utilization of the forces of nature.

All the great civilizations of the past were based on some form of human bondage. The ancient had outright slavery. In the Middle Ages it was called serfdom, but for all the fine distinctions historians have tried to make between these terms the basic idea was always the same: In pre-technological times a civilization was looked upon as an organism, like a flower. And for a flower to bloom and to turn its blossom toward the light, its roots, which give it the strength, must dig in the dirt.

For humanity's survival a certain amount of unpleasant, heavy labor had to be performed. Mechanical means for doing that dirty work were unknown. Therefore human bondage for all but a happy few appeared to be a God-given necessity, and a logical and even vital institution in the pattern of the creation.

This simple logic seemed so obvious that even the great thinkers of antiquity—and among them were the originators of many of the most fundamental ideas of the Western World—found nothing offensive in it.

Technology, the submission of the forces of nature, is man's first and only chance to abolish effectively the curse of slavery, whatever its name. Only with the help of technology can we hope to build a cultural organism in which not just a favored few, standing on the shoulders of the multitude, may blossom, but one in which everybody has an equal chance to deploy his capabilities in the light of universal freedom.

We are on our way to this lofty goal, but we have not yet attained it. In fact, in its first phase the technological revolution probably created more new problems than it solved. It speeded up the growth of the large cities where many a farm boy traded the freedom and beauty of life on the farm for the ugliness of a crowded existence in a smokefilled industrial city. It created great riches on the one side and inadequate benefits for the workers on the other, with resulting unrest.

It created a new representative of human bondage—the proletarian, a slave who was no longer for sale but for rent. Theoretically of course, the proletarian was a free man, but the penalty for his deserting the job was still the same as that for the slave of ancient days—death by starvation.

We are still surrounded by sad remains and reminders of this early phase of the technological revolution. The lot of many miners is still reminiscent of that of the Biblical Hebrew slaves who built the pyramids, and the monotonous job of an assembly-line worker still has a conspicuous resemblance to that of an ancient galley-slave.

But the new paradise which the technological revolution promises is no longer a mere silver lining on the horizon. We have unmistakable signs of its imminence. Our highways are no longer built by road gangs toiling with pick and shovel but by cigarette-smoking operators sitting on heavy road-building machines. Assembly line workers are rapidly being replaced by electronically controlled automation of manufacturing processes.

The stoker of an electric power plant who, half a century ago, half-naked and sweating had to shovel coal into blazing fires, now sits in a tile-covered control room clad in a white gown and monitors the instruments of the automatic fuel controls. No longer does he live in a cold water city flat. He has his own little suburban home and drives his own car.

The technological revolution has brought about an entirely new set of unprecedented problems for the organization of human existence on this planet. In fact, most of today's political problems are a direct consequence of the technological revolution. Capitalism, socialism and communism were unknown words before the invention of the steam engine. So were terms such as trade unions, raw material bases, transoceanic supply lines and oil concessions.

One of the most crucial problems of our times lies in the fact that the very nature of technology is dynamic, while the forms of political law and order which mankind needs for peaceful co-existence are fundamentally static.

The contradistinction between the static forms of political order and the rapidly changing technological conditions is likely to create in the future, as it has in the past, a continuous source of conflict. For every major invention changes the basis of human existence far more profoundly than a treaty between nations or an agreement between statesmen.

The overshadowing prominence of the technological revolution is impressively manifested by the fact that it knows no national boundaries. Its unmistakable signs—smokestacks, roads, railroads, power lines and industrial cities—can be found on both sides of the Iron Curtain, in America and Europe, the birthlands of modern industry, as well as in historically agricultural Russia and China.

It has spread like wildfire to South America and Australia and is establishing ever firmer footholds in the darkest parts of Africa. Even spiritual India—where since time immemorial men had held that the only road to human happiness was abstention from worldly ambitions, goods and riches—is now competing with the rest of the world in the construction of hydro-electric power plants and the operation of transcontinental airlines.

But while the enthusiasm for the technological revolution may be the same on both sides of the Iron Curtain, there are truly fateful differences in its implementation.

We in the West take account of the fact that the prime mover of technological progress is man himself; man, with his hopes, dreams and imaginations; man, with his enthusiasm and pride of accomplishment; but man also with all his foolishness and weaknesses, with his personal ambition, greediness and thirst for pleasure. We believe in a free society where man can pursue his own dreams, follow his own ambitions and form his own life.

We believe in limiting his activities only to the extent as they might harm his fellow citizens, and we are entirely ready to accept even his weaknesses such as egotism and search for easy profit as natural and human and smilingly put them to work.

We subscribe to the belief that the rich man's luxury of today is the average person's consumer goods of tomorrow. The result of this general attitude is an economy governed by an all-out effort by everybody to be more effective than his competitior.

We must push the spokes of the wheels of progress in order not to be run over ourselves. But while we are throwing everything we have into the fight, we must concede that we are using some of our strength, not against the forces of nature which we set out to harness, but against our business rivals.

On the other side of the Iron Curtain this free-wheeling way of going about the business of progress is considered wasteful. In accordance with the basic communist creed that there should be no private ownership of means of production, the State took over the management of the factories and laboratories.

Not man himself, as a warm-blooded individual, was to be the hub of progress but an all-embracing and all-controlling master plan. Whole series of consecutive Five-Year Plans were thus enacted which, on paper at least, provided an admirably dovetailing set of schedules for the organization of industrial development and progress. The gear box of this gigantic machinery, the purpose of which was to convey the driving power to its many outlets, was grandiose, but soon it became apparent that what had failed was the motor itself: man.

At first, communist revolutionary enthusiasm was supposed to step in and provide the driving energy which had taken a nose-dive when, because of lack of incentive, the personal interest of the individual had faded.

After the storm of enthusiasm had blown itself out, an appeal to proletarian solidarity was called upon to replace it. And after this had failed, too, naked terror was tried as the last resort.

While it succeeded in keeping the wheels of the machinery from grinding to a complete stop, the results were so disappointing that the Soviet leaders themselves realized that the re-introduction of incentives—which, of course, was tantamount to a differentiation in the standard of living—was an absolute must if their great Soviet economical experiment was to be saved from monumental failure.

The Soviet leaders were confronted with yet another problem which compelled them to return to an effective incentive system. While their Communist Revolution could be run and was run by political amateurs, the technological revolution can only be run by professional scientists and engineers.

Without an adequate educational system capable of producing a steady supply of scientists and engineers to direct the work in their factories and laboratories, they could not hope to catch up with the Western World's advances in technology. And without continued progress in the realm of the technological revolution, their political revolution would have been doomed. For it would have been demonstrated for all the world to see that communism was not capable of industrially organizing a backward country.

We know how frighteningly successful the Soviets have been during the past decade in producing ever-increasing numbers of scientists and engineers. But while this development—and its consequences on the future economic and military position of the West—should be given all the serious consideration it deserves, we should not lose sight of the fact that it contains a very strong element of truly bright hope. For there can be no scientific education without encouragement of a critical attitude on the part of the student.



Dr. Wernher von Braun with a model of his famous "pioneer model" manned space rocket.

There can be no scientific progress without a healthy disregard for the printed word and for dogmatic truths established by authorities or famous predecessors. And no man can be a true engineer unless—like a medical man—he looks upon his job as a calling, as an opportunity to make a contribution to the technological progress for the betterment of man's life on this earth.

I am convinced that the education of those hundreds of thousands of scientists and engineers in the Soviet orbit will have its lasting effects on the Soviet system itself. It will make it more and more difficult for the few to impose their will unchallenged upon the many. Those hundreds of thousands of critically and scientifically trained minds will cause more discussion, criticism and "feed-back from the bottom". They will, in general, mellow the Soviet system's monolithic structure. But most important, they will, in the long run at least, enhance the role of ethics in the Soviet system and will reduce the role of momentary expediency.

It is my firm belief in the ennobling effect which this mass-education program will have on the Soviet system, that affords me my optimistic outlook on the future of mankind.

Our present, sometimes seemingly hopeless, political impasse with the governments behind the Iron Curtain shows us with a frightening clarity that all of man's scientific and engineering efforts are in vain unless they are performed and utilized within a framework of ethical standards commensuate with the magnitude of the scope of the technological revolution. The more technology advances, the more fateful will be its impact on humanity.

If the world's ethical standards fail to rise with the advances of our Technological Revolution, we shall all perish. Let us remember that in the horse-and-buggy days nobody got hurt if the coachman had a drink too many. In our times of high-powered automobiles, however, that same drink may be fatal!

The successful release of atomic energy presented mankind, in one neat package, a simple choice between hundreds of cheap electrical slaves for everybody—and universal destruction. With the rocket, the technical differences involved are even less. Any ballistic missile capable of carrying a nuclear bomb over an intercontinental range can be modified to carry a few instruments to the moon. In both cases the question of which of the two loads will ultimately be placed into the nose of such a missile is not in the hands of the scientist or engineer who builds the rocket. It is solely dependent on what

ethical standards will prevail in the world in times of crises.

Technology and ethics are sisters. While technology controls the forces of nature around us, ethics controls the forces of nature within us. But while technology is a mere 150 years old, the problems of ethics have occupied the minds of the greatest thingers on this planet for several thousands years.

I think it is a fair assumption that the Ten Commandments are entirely adequate, without amendments, to cope with all the problems the technological revolution not only has brought up, but will bring up in the future. The real problem is not a lack in ethical legislation, but a lack in day-to-day ethical guidance and control.

Prior to the Renaissance the church applied this tight individual guidance to emperor and beggar alike. But when science freed itself from the bonds of religious dogma, thus opening the way for the technological revolution, the church also lost much of its influence on the ethical conduct of man.

It has been frequently stated that scientific enlightenment and religious belief are incompatible. I consider it one of the greatest tragedies of our times that this equally stupid and dangerous error is so widely believed. But it is easy to see why so many people fall for it. We instill in our children a tremendous amount of what we call factual knowledge, but we deny them knowledge of what we do *not* know: "You can't teach what you don't know yourself," is the cheap excuse. But by not telling the children about nature's mysteries, its infinite number of unexplained and unexplainable miracles. we deny them that most important dowry for their future life, humility.

Nothing has probably retarded human progress more than idolatry of our own achievements. By adoring our own scientific achievements we kill humility, the mother of any true scientific progress. By adoring our own technological advancement we kill the urge to come up with a better product.

Nature around us still harbors many thousands times more unsolved than solved mysteries and for all our scientific enlightenment we know more mysteries today than when the technological revolution began. So there is no reason why God cannot retain the same position in our modern world that He held before the natural sciences began to pierce through the walls of dogma erected by the church.

Science and scientists should put this simple but widely unknown truth across to people everywhere. With all the modern means at our disposal, with schools, churches, educational institutions, press, radio and television, we should tell the world that religion and science are not incompatible; that, on the contrary, they belong together. For only with God reinstated in the heart of the world, will He furnish mankind and its leaders the ethical guidance through the dangers and pitfalls of the technological revolution.

The fear of the nuclear bomb, the restlessness of modern city life, the standardization of many consumer goods with its resulting levelling effects on tastes, fashions and even opinions—in short the unpleasant aspects of our technological age—have caused many people to decry technology as a whole and to preach return to the simple life. But for any civilization that has entered the road of technology, and there is hardly any civilization on this planet left that hasn't, there can be no return. For it is in the nature of the technological revolution that it first destroys the existing economic pattern before it can effectively replace it by a superior one. Thus for a country dedicated to industrial development to return to the simple life would mean complete economic ruin. There is only one way to overcome our present difficulties, namely to pursue the technological revolution with even greater zeal and determination.

But in order to keep the technological revolution alive, it must be continuously incited by research. Only by feeding it with new discoveries and new inventions will it continue to roar along the road of progress.

One of the main ingredients of any research or exploratory work is just plain curiosity. It is as unwise as it is unrealistic to insist on justifications for new research projects on the basis of their immediate purpose and their potential practical application. Technological history abounds with examples proving that it is simply beyond the capability of man to predict what will follow in the wake of a major discovery.

I do not know of an example which could illustrate this simple truth more strikingly than that grandiose project so dear to the heart of every true rocket man: flight into outer space. How often have we heard questions such as "Why should we try to establish artificial satellites?" or "Why do you want to go to the moon?", questions hopelessly ignoring the mainspring of human existence. The simple fact is that we have the technical means at our disposal to go about these challenging tasks; therefore, the only really justified question should be: "Why should we *not* do it?"

Space flight is not just one of a great number of technological projects of the near future. It is in a class all by itself because it means, in the broadest sense of the word, an extension of man's activities beyond the realm of his home planet. Today when we talk about space flight we think mainly of rocket ships and their engines, of guidance and navigation methods and of the technical means for controlling the environmental conditions aboard a space ship.

These engineering problems are really only part of the broad aspects of space flight. They are a very important part to be sure, because it is still the lack of adequate transportation equipment that prevents us from traveling to the moon and to Mars. But once these means of transportation are available, research activities beyond our own planet are bound to fan out tremendously.

We can get an inkling of what we may expect in this regard from the rush of research institutions on the rather modest payload accommodations for scientific instrumentation on the *Vanguard* satellite rockets. Thus we may safely assume that once laboratory space in manned space stations is for rent, we shall run into all kinds of professions up there which have very little concern with the engineering aspects of rocket ships.

Of course, we shall find astronomers and astrophysicists, radiation experts and medical researchers, meteorologists and reconnaissance men up there. But commercial interest will have entered the field, too, and we should not be surprised to find a sign at some door indicating a maintenance headquarters for an orbital ultra high-frequency message relay center for a television relay station.

But once man sets foot on the moon and the first voyages to our nearer planets are in preparation, new professions will join the cause of space flight. Botanists and zoologists, geologists and archeologists, mapping experts and may be even interplanetary mining prospectors will be represented in man's first interplanetary expeditions.

It is difficult to think of a field of human endeavor that will not be involved in man's greatest venture. Thus it is only natural that space flight has moved to the forefront of scientific research.

It is the ultimate objective of our great technological revolution to free man from the slavery of heavy physical labor, to elevate mankind from its historical bondage to a race of masters, in whose service toils an army of mechanical and electrical slaves.

This liberation through technology will enable man to devote more time to think and to dream. It will raise all our civilizations to levels never before attained in human history. Space flight will free man from his remaining chains, the chains of gravity which still tie him to this planet. It will open to him the gates of heaven.★



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PROPULSION PROGRESS

Some twenty years ago, a backyard static test of a new chemical propellant combination was likely to add some 25 seconds to the increasing specific impulse climb at a cost of a few dollars. Today we are groping for increases of only a few seconds at costs of from four to six orders of magnitude greater. And, our propellant future, limited by known compounds and problems of stability, seem to be headed to a maximum level plateau of about 300-350 seconds for working systems. It is expected that it will take us some ten years to reach this ultimate in chemical propulsion.

Despite this now very gradual climb, there is a vast technology and a new industry being forged to support the progress that already has been made. Here then is where the real progress is being made—concerned with production, stability, logistics, economics, and the expanding market of applications.

Biggest propulsion advance lies in the field of "exotic" fuels. Since we had only a handful of good oxidants to play with, it seemed logical to look for improvements—particularly heat content—in our fuels. The light metals and the various hydrides all offered higher heats of combustion per unit volume than conventional hydrocarbons. These exotics are now getting into production. Known under the name of "Zip" or "Hi-Cal," the exotics apparently are hydrides of boron which can be used directly or as a "Mickey" for common hydrocarbons. Presumably the exotics will be slated for use in jets, ramjets, or in rocket systems.

Although details of the exotics are just starting to trickle out, it is probably safe to say that the laboratory phase has been completed and that the main effort is now centered in building production plants. Within the next two years, the production of exotics will have assumed the tonnage scale. Only then will a true balancing out take place. This balancing out will weigh the actual operational advantages against such powerful factors as handling and logistics, demand versus production and overall cost. Commercial applications of the exotics hang on the comparison of laboratory expectations and actual practices.

Right now, straight LOX seems to be the choice of all large missile systems. However, the days of LOX for some applications are already numbered. Several years of work have gone into the preparation of pure ozone and, as the exotics are used to "spike" the hydrocarbons, ozone will probably be used for increasing the oxidizing power of LOX. As yet, however, straight ozone is a bit difficult to handle and ozone technology has not yet operated on any scale but laboratory operations.

Liquid fluorine (or fluorine compounds) is closest to displacing LOX. Nearly everyone agrees that fluorine offers a good balance between high flame temperature and low molecular weight. Since fluorine will probably offer the ultimate in oxidizing potential and give nearly the theoretical limit for chemical systems, the path for fluorine is well marked. And fluorine, unlike ozone, has well established handling techniques and is now being produced on a tonnage basis.

For smaller systems, nitric acid will continue to be a popular propellant. Other propellants such as hydrogen peroxide, ethylene oxide, the alkyl nitrates are already being relegated to auxiliary propulsion systems. Research, however, has failed to turn up stable liquid monopropellants in the 200-250 sec range.

In order to come up with high energy monopropellants, two "dirty" systems are under investigation. One employs what might be called a composite liquid propellant, premixed amounts of oxidizer (such as nitric acid) and fuel. Stability is the big problem here. The ten foot pole is gradually getting shorter as the "gunk" liquids are appearing more attractive to the engineer who formerly would only consider pure or "clean" liquids.

The gunk propellants—gels, slurries, pastes, suspensions, etc.—are being considered for new systems—particularly where high heats of combustion and high volumetric loading are essential.

In between the liquid and solids are the hybrid systems. Two systems have been evaluated in hybrid rockets. One used liquid oxygen which burned a solid polysulfide rubber while the other used hydrogen peroxide and a polyethylene plastic fuel. Neither systems have shown great advantages over either the true liquid or solid system.

This does not necessarily hold for the reverse case where conventional or exotic fuels are used in combination with pure solid oxidants. Work in this latter system, however, has been very sparse. The effort going into the solid fuel ramjet is not as sparse. Several groups have been engaged in development and several systems employing solid fuel ramjets are in the works.

The biggest single important solid propellant development has been concerned with scale-up for producing really large single grains. Both composites and double base castable propellants have evolved which now permit grains of almost any size. However, just how large are current big grains is difficult to ascertain because of security reasons.

It is probable that present solid propellant technology can give grains of about 1 million lb-sec and that within 2 years we will have solid rockets as large as the V-2 (ca 4 million lb-sec) and that in 5 years an operational solid propellant IRBM will have been developed.

At the other end of the solid propellant scale, ammonium nitrate is ushering in the era of low cost, medium energy sources. It is already being used in the area of RATO and boosters. Biggest area for these propellants are APU's and a host of industrial and commercial applications.

Newest entry into the propulsion field was the continuous detonation engine. Although thrusts are yet small, the specific impulses are quite good. Since this work is yet in the laboratory stage, extrapolation to large-scale hardware is difficult.

The next propulsion plateau above chemical propellants will probably be the use of nuclear energy. In the atomic rocket, propulsion progress is of a mixed nature. The stretching out of our aircraft nuclear propulsion program has been blamed on excessive weight and a high level of radiation. In the power reactor field, however, progress is being made in increasing heat transfer by increasing pile temperatures. Developments now taking place in other realms, however, may never make the thermonuclear rocket practical.

There is a great deal of interest in non-heat engines. Two entries for study of ion propulsion have been let and there are a host of researchers working on electrical and magnetic particle acceleration. Fusion energy for rockets is a hope, although distant. And the ultimate of all propulsion schemes—the utilization of photons—still awaits a laboratory foundation.

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FIRST IN AVIATION

Engineering Progress in Air Force Rocketry

By Frederick I. Ordway III and Ronald C. Wakeford

RECENT TEST FIRINGS of nuclear armed air-to-air rockets spotlight the progress made in aerial warfare. Although overshadowed by the more spectacular developments of IRBMs and ICBMs, new advances in aerial rocketry have caused revolutionary changes in the tactics of plane-to-plane combat.

The design and development of a successful air-to-air missile is a complex proposition with enough variables to keep teams of engineers and scientists busy for months and years. Not only must the missile operate in harmony with the aircraft that carries it, but all internal mechanisms must be carefully mated with the missile itself.

The *Firebird* represents a relatively early attempt by the Air Force to provide an accurate liquid-propelled air-to-air missile for operational units. It was developed in about two years by the Ryan Aeronautical Co., and carried the official designation XAAM-A-1. It was first tested in 1949, was carried on external launching racks.

Firebird incorporated a semi-active radar homing system and a proximity fuze. Control surfaces were located on the wings and fins. The carrying airplane housed the search radar.

The 7½-foot missile (10 feet with booster) had two sets of cruciform plastic wings with control and stabilization surfaces. The basic structure was conventional aluminum alloy sheet. Such aircraft as the B-26 and *Twin-Mustang* F-82 generally carried four of the 600 pound Firebirds, which could be fired alone, or in groups of two or four. The overall development program cost about $2 million.

Mighty Mouse

For years America's only operational air-to-air rocket was the reliable 2.75 inch, folding fin unguided *Mighty Mouse*. If hostilities were to break out today it would continue to be a standard defensive weapon. *Mighty Mouse* was a Naval Ordnance development of the successful German R-4M rocket of World War II, and has been fired not only from such Navy aircraft as the *AD Skyraider*, but flown many Air Force fighters. The *Aeromite* is much like the *Mighty Mouse*, using a somewhat different propellant.

The rocket uses a proximity fuze, and has fins that fold out at launch. Some airplanes, for example the F-89 and -04C, carry them in wing tip pods to improve dispersion, firing about twelve in a quarter of a second. Other planes, such as the F-86, fire them in single volleys of 24, leaving the aircraft at 200 miles per hour.

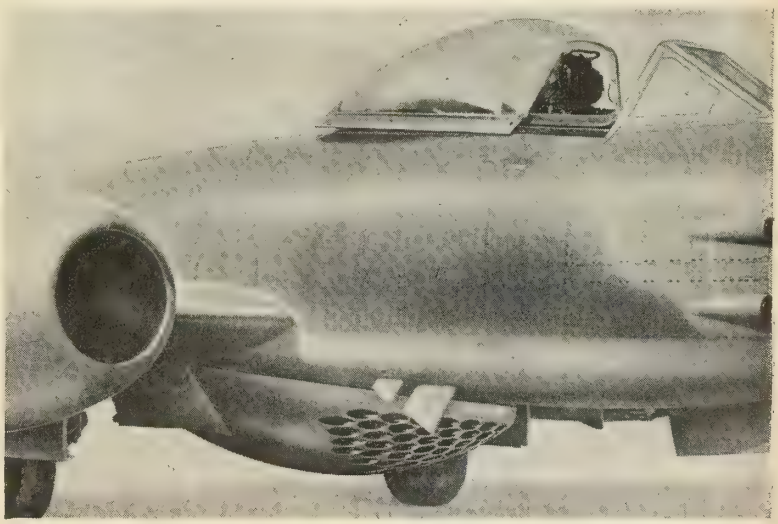
The F-89D can carry 104 of these 2.75 inch rockets and fire them electronically. A T-110 rocket gun has been developed to fire the *Mighty Mouse*.

Mighty Mouse has been in production for years and is used throughout the squadron service. It is used in practice shoots against aerial towed targets like the radar-reflecting nylon marquisette units currently in vogue. B-45 and B-57 aircraft generally tow the targets for practice shooting with the *Mighty Mouse*.

There is considerable pilot disagreement about the relative effectiveness of launching salvos from trays under the nose and from wing-tip pods. While accuracy from the former position may be high, pilots point out that by loosing your rockets from wing positions you can get more rounds on a target per pass, better dispersion characteristics, and hence a greater chance of destroying it.* In the case of the *Mighty Mouse*, cost is not an important factor which helps make it an attractive defense item.

Eglin Air Force Base is supposed to have a fully developed two-inch replacement of the *Mighty Mouse*, which was shelved because of long-term *Mighty Mouse* commitments, and

* A dispersion of 20 miles means a deviation of 20 feet for 1000 feet of travel. Unguided rockets are normally spinstabilized, though longitudinal fins often provide prime stability. The higher the number of rpms, the more dispersion is reduced.



Swiss Oerlikon's bid in the small air-to-air folding fin rocket field. This launcher for 76 of the five centimeter diameter projectiles is mounted on a British Gloster Meteor twin jet fighter. Some pilots perfer the straight ahead firing of this center mount to the converging pattern obtained when the rockets are fired from wing-tip pods.

because of current emphasis on air-to-aid guided weapons.

Zuni

Named for the Pueblo Indian Tribe, the new Navy *Zuni* air-to-air 5 inch high velocity aircraft rocket was developed by the Ordnance Test Station, China Lake, Calif. This folding fin, solid propelled weapon has been extensively tested by both BuOrd and the Fleet Operational Development Board, and is now approved for operational use. It has twice the velocity of the HVAR of World War II fame.

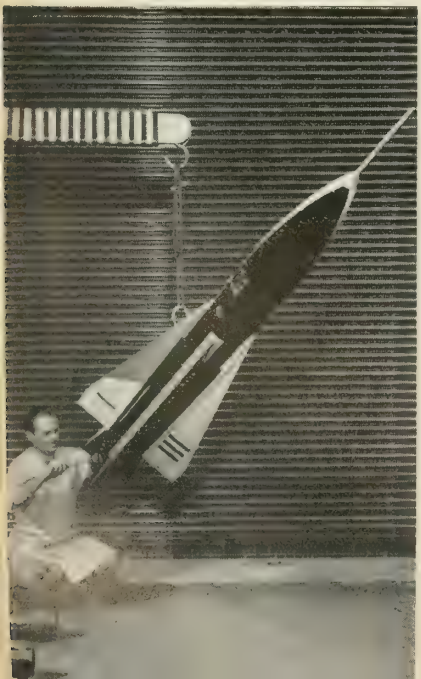
The *Zuni* launcher can accommodate four rounds and not only launches the rocket but is also the storage case. It is jettisoned after use. The elimination of the normal packing case is expected to result in considerable time savings. *Zuni* is also designed for air-to-surface applications.

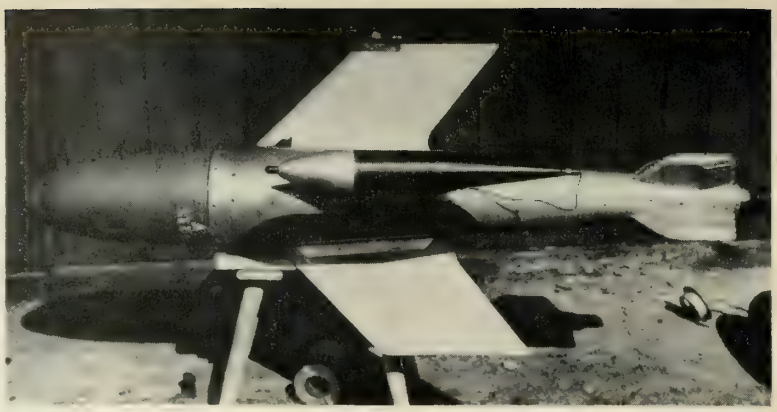
The unguided rocket generally has good static stability and reports indicate that *Zuni* is no exception. Detailed performance figures, however, are not yet available. In guided rockets, on the other hand, one must allow for a large displacement of controls to maintain a given flight path or to change direction. With relatively low static stability, they enjoy a high maneuverability rate.

Sparrow

There are three *Sparrow* missiles now in existence: *Sparrow I* (AAM-N-2), *Sparrow II* (AAM-N-3) and *Sparrow III* (AAM-N-6), developed respectively by Sperry-Rand, Douglas and Raytheon. *Sparrow IV* is apparently still under the cognizance of Navy BuAer, and as far as is known no contractor has been designated to build it.

An approach to bomber defense this Cornell Aeronautical Laboratory missile design looks like but actually preceded that of the HAWK.





German X-4 was developed as a wire controlled, rocket propelled, gyro stabilized missile. It employed a proximity fuse. By the time World War II ended it was almost ready to use.

Sparrow I, first produced in 1951, is manufactured by the Sperry-Farragut plant in Bristol, Tenn. and at the Douglas Aircraft Co. in Calif. A beam-rider, it has a semi-active terminal homing device developed by Sperry and Raytheon. It is considered very accurate up to five miles.

Sparrow II, with an active homing system is to be used by the Royal Canadian Air Force to replace its abandoned Velvet Glove development. It has a rounded nose, trapezoidal form, and shortened fins.

Raytheon will build *Sparrow IIIs* at Sperry's Bristol plant when *Sparrow I* phases out. This new missile has been mounted on McDonnell F3H Demons.

It is radar guided, has a blunt nose and tail surfaces similar to *Sparrow I* with a smaller degree of sweepback. Raytheon has a $60-million Navy contract for its air-to-air work. *Sparrow I* has seen wide operational use on McDonnell F3H2N *Demons*, Chance-Vought F7U3M *Cutlass*, and other aircraft.

Falcon

Under development since 1947, the GAR-98 *Falcon* is a product of the Hughes Aircraft Co. and Philco. The three-to-five mile missile has been carried by a wide variety of aircraft including the F-86, -89, -94, -100, -102 and CF-100, and was first tested in 1950. The F-89H was the first operational aircraft to carry *Falcon*, which has been mounted on both wing pods and pylons.

In the pod mounting layout, three *Falcons* are often carried on the periphery. The pod itself contains three 7-battery 2.75 inch rocket panels. An interesting feature of the *Falcon* is its temperature sensitivity. For this reason special heaters are used to maintain the firing temperature. In solid rockets this temperature sensitivity is expressed as the percentage change of thrust for each unit of temperature change and generally runs from 0.0025 to 0.014 additional pounds of thrust per degree. On hot days you get a higher thrust while lower than rated thrust may occur on cold days if no heating blanket is used.

GAR-1 (Model 1) is six feet long and six inches in diameter, weighing 112 pounds. Newer models are longer and heavier, and have a greater range. Four have been placed in production since the inception of the program. The latest is the GAR-1D, featuring major control changes. Since atomic explosives reportedly can now fit into four-to-five inch diameter projectiles, *Falcons* with atomic warheads may be approaching.

Falcon may eventually be made in an infra-red version using a beam rider guidance system with semi-active homing. Whether Models 2 or 3 will have it is not known. The missiles can be fired from any positions including underneath and in salvos beyond the defensive range of a bomber.

As production goes up, costs go down. A few years ago figures of $25,-000 to $50,000 were quoted for *Falcon* Model I. Now it costs about $10,000. Rumor is production runs over 100 a month.

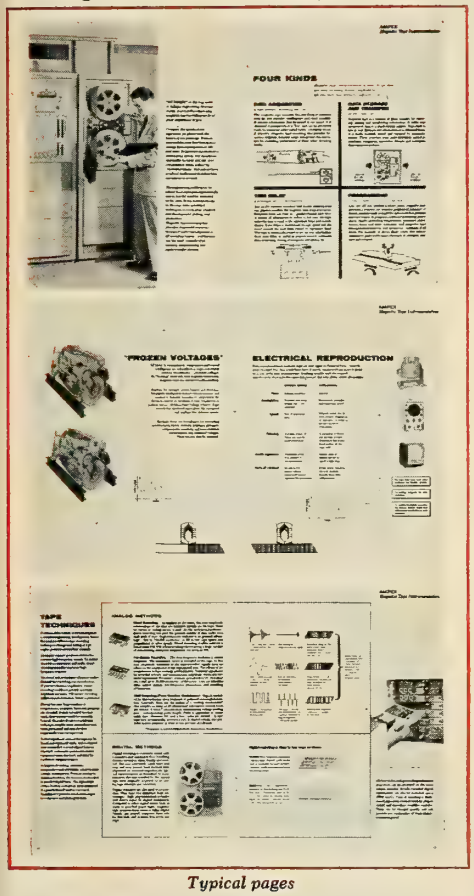
Sidewinder

Infra-red guided *Sidewinder* (AAM-N-7) is one of the Navy's latest aerial weapons and is operationally installed on jet airplanes operating from both land and sea bases. Seen mounted on pylons under the wings, the missile is reported to be one of the most accurate in the business, having successfully knocked flares off the wing tips of an F6F drone without causing sufficient damage or de-

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flection to the vehicle to prevent its later recovery.

The infra-red guidance package producing such pin-point accuracy is the first of its type to reach operational status. *Sidewinder* is operational on F9F, F3H-2N and FJ3 aircraft, and sees service with Attack Squadron 46 on the *U.S.S. Randolf* and Fighter Squadron 211 on the *U.S.S. Bonhomme Richard*. It is effective up to 50,000 feet and has an accurate range of about 3500 yards. Contact and ambient fuzes are provided.

Some Navy fighter airplanes carry both radar guided *Sparrows* and infra-red guided *Sidewinders* at the same time. Since infra-red is ineffective in rain or heavy clouds, radar is handy under these conditions. Infra-red is rather difficult to fool, but it can be done.

Bombers, however, can generate powerful interference for radar signals flowing from the intercepter to the missile. Since neither radar nor infra-red is perfect we expect that unguided barrage rockets will form a secondary defense for some time.

Sidewinder is stabilized by attaching small bucket wheels to control surfaces and rotating them at high speed. Performance of *Sidewinder* has attracted the attention of the Air Force which it may mate with the F-104 Lockheed fighter.

The missile is currently delivered by Philco which originally assisted the Naval Ordnance Test Station, China Lake, Calif., in its development. *Sidewinder* is characterized by a blunt nose, four triangular forward fins and four rectangular surfaces aft.

It has been reported that the *Diamond Back* will succeed the *Sidewinder*, and that it, too, will be infra-red guided.

Ding-Dong (MB-1)

Little information has been released on this new, atomic-tipped, liquid propellant, air-to-air missile. Although 1956 is considered the year of its conception, warhead tests were made in the spring of 1955 at the AEC's Nevada test areas to provide basic information on the missile's requirements.

The missile was reportedly flight tested with its A-warhead during the May 1957 AEC atomic firings in Nevada. Developed for the Air Force by Douglas Aircraft Co., it is the first nuclear warhead rocket in the U.S. for air-to-air operations. A solid propellant version is currently reported under development.

Ding-Dong MB-1 (the name *High Card* may once have been used) is to be tested on F-89J, F-102 and F-106 airplanes. The Hughes Aircraft Co. is presumably handling the control problem. Air Force says that it will stock A-warheads for the missile at various points around the country.

The *Tingaling* is a training version of the *Ding-Dong*, with a spotting charge only. Air Defense Command uses it.

A number of air-to-air missile programs were cancelled before they were through the development stage. Navy BuOrd's *Meteor* project, handled by the Massachusetts Institute of Technology, was one of these. Active until 1951, the missile weighed 500 pounds, carried a 25 pound warhead, and was to have flown at Mach 3. Some work on it was reportedly done by the Bell Telephone Laboratories.

The Martin *Oriole* XAAM-N-4 BuAer-sponsored missile program was cancelled in 1954. Little is known about it except that it was to have a range in the neighborhood of ten miles, and was to fly in the Mach 2 region. It may have been ramjet powered.

Among the active programs in the U.S. about which no details are currently available is an air-to-air missile under development by Republic's Guided Missile Division.

Bomber defense missiles are currently receiving considerable attention. It has been widely circulated that Cornell Aeronautical Lab's BDM is merely a modification of the *Hawk* surface-to-air missile. CAL insists, however, that such is not the case, that their missile is a test vehicle specifically designed for bomber defense, and that not only is it completely independent but preceded the *Hawk* design.

The Air Force has long kept an eye on the missile as a possible defen-

Ryan Aeronautical Co. FIREBIRD used radar homing and proximity fuse; was one of first guided air-to-air missiles in U.S. Bottom shot shows MIGHTY MOUSE package on F-86D.





sive weapon for bombers and B-52's may soon be carrying them. This interest probably dated from the time German jet-powered intercepters began to invade American bomber formations in World War II, attacking with 50mm cannon from the rear.

Some investigations were made to adapt 2.25 inch and 5 inch spin-stabilized rockets for such use. To launch rockets from the rear of modern, high speed jet bombers present a series of complex problems including aerodynamics, guidance and control.

One project under study was the 1½ inch caliber *Nasty*, which was given spin stabilization by canted rocket nozzles and canted fins. Its high velocity kept it from weather-vaning when fired sidewise to the rear of bombers. Initial boost was provided by rocket guns, presumably the T-132 known to fire short, 1.5 inch rockets. This North American Aviation development has been cancelled by the Air Force.

Both the *Duck* and *Goose* have been mentioned as missile weapons to be carried by the *Hustler* B-58. Whether either or both have a BDM application is not known.

Air-to-Air Warfare

Air-to-air rocketry requires much in the way of pioneering to develop and maintain invulnerability and accuracy. Weapon and counterweapon have been the order of the day since the earliest battles, and counterweapons from shields and armor to antimissile missiles have always been available to plague the tactician.

The guided air-to-air missile has not yet been tested under real combat conditions. The air-to-air missile is a formidable weapon if only from the viewpoint of the tremendous closure rates to be anticipated from interceptor and attacking intruder, both travelling in the supersonic speed range.

Presumably an optimum air-to-air weapon system must prevail over a maneuvering target and decoys and electronic countermeasures, to say nothing of terrain and weather conditions. The latter are particularly important when the opposing force attacks at low levels.

Prior to combat and without a completely automatic fire-control system, an intercepter has to go through several maneuvers, each susceptible to error. Upon being vectored into position by ground radar through possible cloud cover and chaff countermeasures, the fighter will have to assume the correct heading or collision course, determine the range, speed and maneuverability of the target and get close enough to bring the air-to-air missile into action.

Once launched the missile must follow the path of the attacker and detonate upon or within a lethal distance of the target. This was the picture of events prior to the introduction of a completely automatic fire control system such as that developed by Hughes Aircraft for use with the *Falcon* missile.



Panel removed shows BMD test bomber defense missile's circuitry for control and guidance.

Ideally, ground radar picks up enemy intruders at maximum range and tracks them. Intercepters are sent aloft and homed upon the attacking force by a control system inter-related with the ground radar, a lead collision course being automatically set and flown.

At a pre-set distance the intercepting aircraft's control system takes over, locks on to the attacking force, corrects for intercept and launches the air-to-air missile. The pilot has very little to do with the whole operation.

Countermeasures would appear to be governed by the following factors: Being warned immediately that ground radar is in contact with his aircraft, the attacking pilot will know that defensive intercepters with air-to-air missiles are to be expected within a short while. His immediate reaction might be evasive action such as dispensing chaff and possibly low level operations.

Presumably he would also make preparations to neutralize the anticipated missiles. Such devices as decoys and standard disruption of radar procedures might be used. In the case of the infra-red type guidance, advanced methods of diffusing heat could be used to deflect the missile from the target. A more expensive and complicated device would be the anti-missile missile which is currently being considered for the *Hustler* (B-58) intruder.

Air-to-air missiles are equipped with a variety of warheads each designed for a different purpose. The isotropic warhead or unoriented charge fragments in all directions while the non-isotropic or directional warhead concentrates its power into a single direction. This latter procedure involves a delicate fuze design to determine the whereabouts of the target.

The blast type warhead was conceived as a high pressure device and has an effect similar to that of a depth charge upon a submarine.

There has been some conjecture as to what effect radiation would have on the delivering agent as well as the target.

In defensive action this weapon presumably would be used only over the sea, large open friendly areas or in enemy territory. The thermal warhead, a fire raiser which can be chemical or nuclear or the environmental warhead, designed to put either the crew or propulsion system out of action by a chemical agent of some kind, can be equally lethal.

The selection of a suitable fuze presents quite a problem to the systems engineer as well as the designer. There are many types although the missile and warhead tend to dictate the design of this extremely important component. The timed, proximity and impact fuzes are commonly used.

Since the destruction of a target is intimately coupled with the detonation of the warhead at exactly the right moment, the correct selection of a fuze will be decisive in any attempt to abort an enemy air attack.

Despite the difficulties inherent in the nature of aerial warfare and accentuated in the air-to-air missile system, new and advanced techniques are continually being developed to make the vehicle more efficient and deadly.★

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Missile Progress by the Corps of Engineers

By Maj. Gen. David H. Tulley, U.S. Army

Commander, U.S. Army Engineer Center

TECHNOLOGICAL and engineering achievement in the missile field has made possible weapon systems of of such potential as to revolutionize our defense organization, tactics and techniques. We find ourselves egging industry on to new accomplishments while scrambling to keep abreast of advances already made.

Pressed by time and the technological advances of others, the Army's Corps of Engineers has been engaged in providing engineering support to the development and testing of the Army guided missile program and the packaged nuclear reactor power program.

Engineering progress in this field is indicated by successful development of such support equipment as the *Nike* ground installation elevator, electrically controlled and hydraulically operated. The elevator brings the missiles from underground storage boxes to above-ground firing positions.

The present *Nike Ajax* elevators are 52 feet long and 9 feet wide; they weigh approximately 12½ tons; the vertical travel is 18 feet. These elevators are being modified to accommodate the larger *Nike Hercules*.

Construction of *Nike* sites is an established mission of the Corps of Engineers. Because of distances imposed by safety regulations, a below-ground site requires only 25 per cent of the real estate area required for above-ground installations.

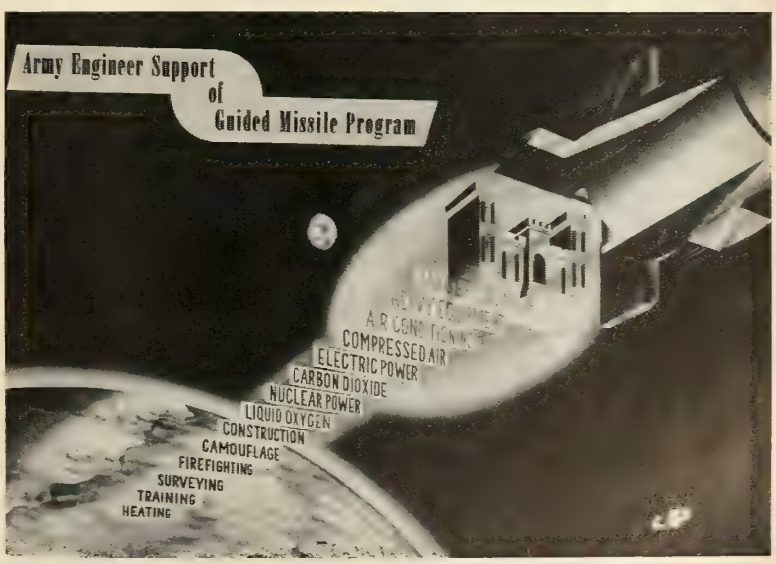
This advantage represents significant economy in expensive metropolitan real estate. Such construction also necessitates installation and control of heating and air conditioning units.

These units are required in radar control vans to assure greater accuracy and lower maintenance. In addition, it is necessary to provide the missile with a positive fuel feed and high control surface reaction against supersonic pressures. Therefore, high pressure air is required.

This high pressure air must be moisture and dirt free. It is supplied by gasoline-engine powered, multiple stage, 3500 psi air compressors. Another part of the Corps of Engineers' share in ground support equipment is the exacting demand for electrical power for the acquisition radars and guidance systems. These systems require both 60-cycle and a 400-cycle electric power.

In the continental U.S. the Corps of Engineers provides frequency converters to change commercial 60-cycle power to 400-cycle power required by the radar vans; 30, 45, 60, and 150 KW generators for standby and for field use are also provided.

The equipment found at *Nike* sites is maintained by engineer-trained anti-aircraft artillery specialists, backed by engineer field maintenance and depot organizations. The engineer-trained anti-aircraft artillery specialists number 1,200 trained each year at the Engineer School. On completion of training, the soldier specialists report to one of the many *Nike* sites.



Army's Corps of Engineers support of the Army's guided missile program is illustrated in this artist's drawing, showing areas of back-up programs conducted by Belvoir engineers.

Progress to date has been significant. Missile ground support has come a long way and we have learned to establish specifications and design criteria for ground equipment in a short time.

Most significant effort of the Corps of Engineers may well be support of the *Redstone* missile. This support is in the field of liquid oxygen. It is rather difficult to handle under field conditions, is vulnerable to enemy action and boil off losses are high.

The LOX units must be air transportable. Working with other military and civilian agencies, the Corps of Engineers has designed and has in production 5-ton per day, 20-ton per day, and 50-ton per day air-transportable LOX plants.

Firing sites require construction effort on access roads and bridges; thus the need for construction equipment in this ground support phase. In non-tactical areas our military construction program meets the demand for testing installations, laboratories and other missile support activities.

We now provide a 25-ton truck-mounted crane with a 90-foot boom to assemble and raise the missile to the firing attitude from transport position.

Solidified CO_2 is the next item. This generated product is used to cool the *Redstone* guidance mechanism. It is necessary to generate the CO_2 in one plant, solidify it in the other and then saw it into "cocktail" cubes for ease in handling and packing aboard the missile. Anticipated development of better heat-resistant electronic components will make this equipment obsolete. However, its retention with our missile fire fighting equipment is assured.

One of the most challenging problems faced by the Corps of Engineers is target location. The system for locating the target must be compatible with the guidance system for the missile.

Map making has been refined and improved but still requires air or ground control of the area being mapped. After survey, data is compiled and the printing done—two tons of 1/50,000 scale maps or 42,000 sheets will be required to cover the trajectory of one missile.

Actually only two sheets are needed, one for the firing site, the other for the target area. Topographic details between these two are of no consequence but the accurate extension of direction (azimuth), elevation and range from the launching sheet is critically important and is a big problem.

Much effort is presently underway in this problem area and considerable progress has been made. Electronic digital computers have reduced by years the time required for geodetic control adjustment. Theodolites accelerate field survey. Geodimeters and tellurometers measure distances electronically. Radarscope photography maps the ground through clouds and darkness. The earth satellite will help too.

The Corps of Engineers is working on electronic systems to locate photographing aircraft with respect to known terrestrial reference points. Perhaps the answer lies in establishing electronic targets in the sky.

If we can establish such a target and hit it, the ballistic trajectory will take care of the rest. We would then be using an electronic cantilever instead of tons of maps for the preplotted trajectory.

Another subject of interest to the Corps of Engineers because of its association with missile programs, is the subject of nuclear power.

The primary military advantage of nuclear power and heating plants is the potential logistic savings in transporting conventional fuel. As a consequence of this reduced logistic load, military operations are less dependent on long lines of supply and, therefore, less vulnerable to enemy action.

Operations can be more flexible since increases in power may be obtained without too significant increases in logistic effort. More electric power from such sources than heretofore available will substantially affect future planning where large quantities of relatively fuel-free heat are desired. The use of small portable reactors in a given situation could make feasible an operation which might otherwise be marginal.

Recognizing the military advantages of nuclear power plants, the Secretary of Defense assigned to the Army the responsibility for representing the military services in carrying out a research and development program with the Atomic Energy Commission. This responsibility within the Army has been placed on the Chief of Engineers.

At the present time, a joint Army-AEC program has been established to develop a family of nuclear power plants to meet the requirements of the three services. The plants are to provide power and/or heat in remote inaccessible locations, devastated areas, combat zones and CONUS disaster areas. The large plants will be capable of use in areas where logistical support is difficult, costly, or vulnerable to interruption by enemy action.

Smaller plants could be developed as mobile or semi-mobile compact power plants for support of military operations in theaters of operation and for emergency power requirements. It is contemplated that the mobile plants will be mounted on trailers or barges and that the larger semi-mobile plants will be in the form of air-transportable modules that can be coupled together rapidly in the field of operation and that can readily be moved after operations. Considerable progress has been made in this field. (See article in June 1957 M/R p. 66) ★

Corps of Engineers Support

It takes research scientists and development engineers to design a missile that works on the test range. But it takes the Corps of Engineers to turn it into an operational weapon.

Nearly every phase of missile field support is the responsibility of the Army Engineer. His duties involve use of such things as missile carrying vehicles, fire fighting apparatus, high pressure air compressors, liquid oxygen generation equipment, fuel and liquid oxygen transport trailers and storage containers, camouflage equipment, electric power generators, cranes and other erector equipment.

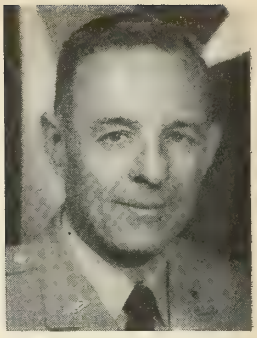
He is a cornerstone in the ABMA structure.

Out of the cooperatives effort with ABMA has grown a vast research, production and testing network—a far cry from the inadequate facilities that housed ABMA two years ago. Additional facilities are being added as needed.

While he is mainly concerned with this construction program, the Army Engineer's job periphery stretches over a wide area and includes problems of missile logistics, mapping and geodesy, troop support, equipment and supplies, chemical, electrical and mechanical engineering.

A typical day might find him making decisions involving the preparation of plans for new buildings, roads or power plants to giving advice on employment and technical problems or on a new mobile LOX plant.

In addition to its support of ABMA, the Corps of Engineers has also been busy at Redstone Arsenal and White Sands Proving Grounds. It is closely tied to technical services activities. The Corps has assigned representatives to these agencies for consultation and to act as liaison.



Progress in Army Missile Research and Development

By Maj. Gen. August Schomburg, U.S. Army

Assistant Chief of Ordnance for

Research and Development

THE EXTREME requirements for accuracy demand the ultimate from the missile guidance and control engineer. Guidance and control systems present problems which probably surpass any others in the history of military research and development. The guidance and control problem encompasses all items necessary in predicting the missile's flight path, sensing deviations from this path, calculating the kind and amount of corrections needed to return to a new predicted path, translating the corrections into commands, transmitting the commands to the control equipment, translating the commands into necessary control forces, and continuously monitoring the overall functioning.

The problem areas encountered in the design and development of accurate guidance systems for Army missiles are further complicated by tactical requirements.

In the field of surface-to-surface missiles, the Army has a need for a family of field artillery missiles to provide all-weather direct and general support for land, airborne, and amphibious operations. These missiles, carrying appropriate warheads, must accurately extend beyond conventional artillery coverage.

They must also supplement and extend the capabilities of support aircraft. They should provide high accuracy and destructive effectiveness on such targets as tanks and fortifications and furnish supporting fire of required accuracy for combat troops making deep penetrations such as airborne assaults or armored breakthroughs.

The characteristics of enemy weapon systems, missiles as well as aircraft, determine the guidance requirements for anti-air missiles. To be of full value in this atomic age an anti-air missile must have the guidance capability to inactivate a hostile warhead. This puts increasing demands on guidance system designers for greater accuracy capability.

Countermeasure invulnerability is a prime requirement of any effective weapon. The counter-countermeasures design objectives may be stated as designing equipment so that successful countermeasures are technically impossible, tactically not feasible or economically unprofitable.

The design of counter-countermeasures features of Army equipment is undertaken at the very earliest date in the initiation of any new missile project. In order to build a system which will most likely be used five to fifteen years in the future, the designer must consider not only existing and proven countermeasures but must ask himself what can be expected in new countermeasure designs during this period.

It is important to allow for future system improvements as new components become available. These enable us to produce an effective system on a tight schedule and still take advantage of new techniques at the earliest possible date.

The design must be confirmed after it is established and tested by the designer. Normally, other agencies are engaged to study the design both from theoretical and practical aspects. These studies, which extend to actual and simulated missile flights where countermeasures are used, lead to many design improvements.

While capture is an extreme case, security leaks can be almost as damaging and planning ahead in design can reduce and eliminate the possibility that a system may have to be abandoned because of a counter-measure compromise.

The Army has and will continue to meet and exceed the countermeasure threat by following this procedure: appraising the counter-measure environment, designing accordingly, critically evaluating the design.

Another formidable problem which the weapon system developer must meet is that raised by propulsion. In the early days of missile development liquid rocket propulsion was the only way to obtain the high thrust and the long burning time necessary to meet the high performance requirements of the system. Liquid propulsion motors were used in such successful developments as *Corporal, Nike-Ajax* and *Redstone* missiles.

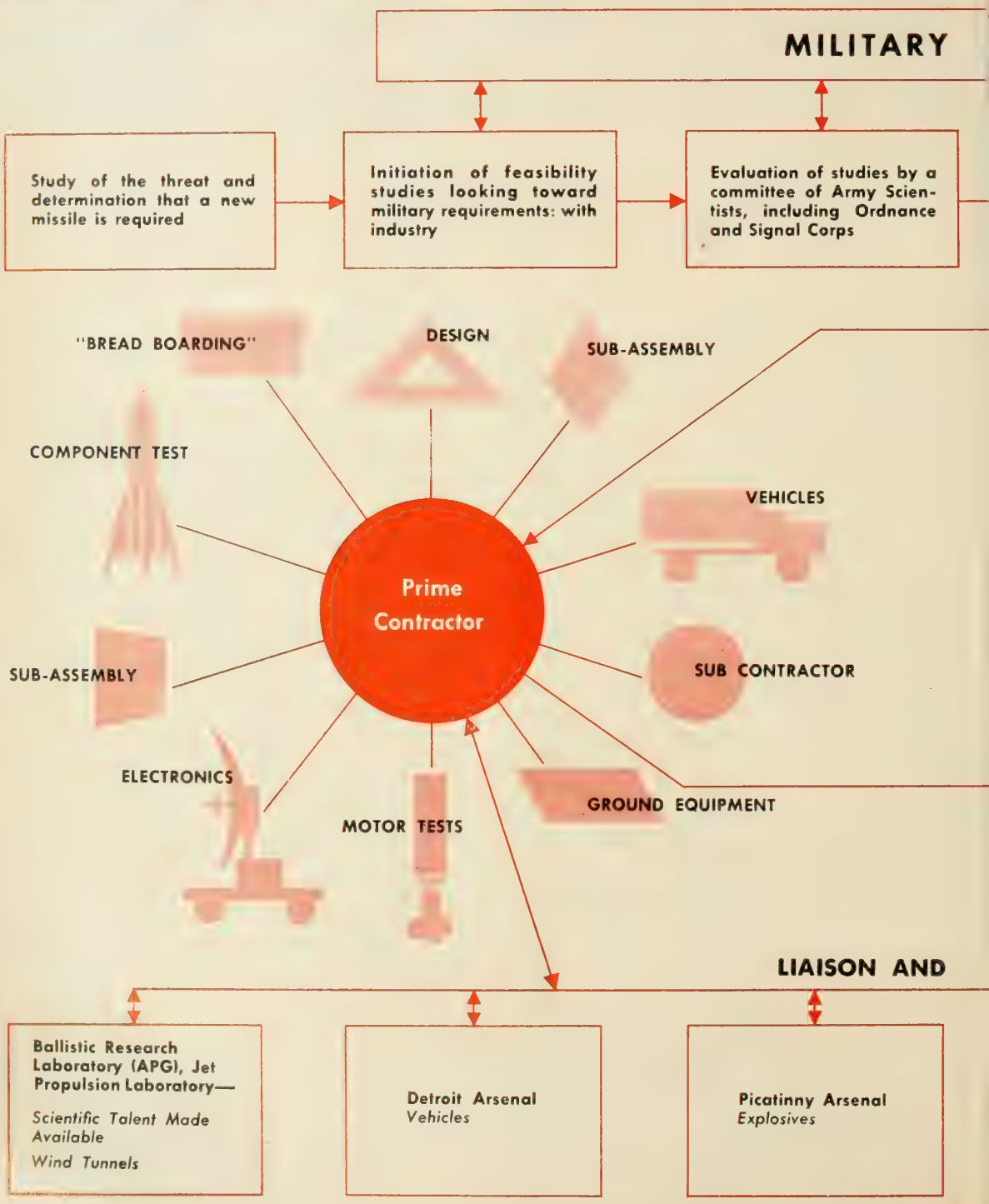
As time went on research and development agencies of the Army Ordnance Corps established the feasibility of adapting solid propellants to the propulsion problem, based on prior successful experience with free rockets using double base propellants.

At the same time, the agencies indicated that ceilings existed for this type propellant. These ceilings limited performance to such a degree that for certain propulsive requirements, other methods would have to be devised.

The restrictions, however, were not sufficiently stringent to void application to such systems as *Honest John,* the *Nike-Ajax* booster and the currently developmental *Little John.*

Anticipating more demanding applications, the Ordnance Corps research agencies devised a new approach to solid propellant development culminating in the composite family. This major breakthrough opened new opportunities of meeting tactical problems previously

PROVIDING AN ARMY



MISSILE | From Basic Conception to Production, One Program Would Follow This Pattern:

CHARACTERISTICS

Selection of best solution

Outline of scope of contract and technical requirements by Redstone Arsenal

Negotiation of contract with selected Corporation by District Office

Continue development: Ordnance Corps engineering testing, contractor's development testing at White Sands Proving Grounds

Engineering Test Program

Info.

Tactical Prototype Test

Planning for Production

Production Engineering

Acceptance and Surveillance Testing

U. S. Army Service Test

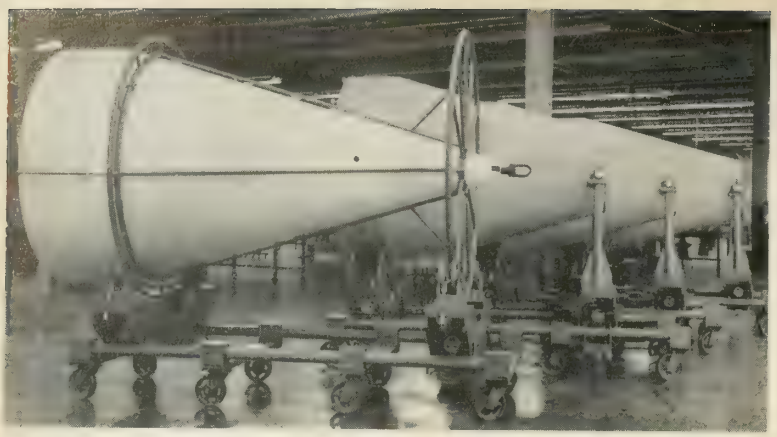
PRODUCTION



TECHNICAL ASSISTANCE

Diamond Ordnance Fuze Laboratory

Steering Committee
Office, Chief of Ordnance
Redstone Arsenal
Army G. M. Board,
CONARC, ARAACOM



Army missile policy: research and development by a coordinated Army agency, production by the American industry. In this case: Redstone nose cones by Chrysler Corporation, Detroit.

considered beyond solution.

With the use of this tool, systems such as *Lacrosse* and *Dart* have been developed as practical front line weapons able to destroy the enemy's defense network while maintaining a high degree of safety for friendly troops.

New vistas of air defense have also been opened by current developments using these propellants in high performance surface-to-air missiles. Continuous evaluation of enemy attack capabilities and persistent research effort in the field of composite propellants, has made defense against the possible ballistic missile threat a reality from the propulsion viewpoint.

While major advances have been made in the fields of accuracy, countercountermeasures and propulsion, technological advances in aerodynamics, mechanics and aircraft design have followed a parallel course.

Current development programs are using data from the still expanding library of aerodynamic and structural information. Transonic, supersonic, and hypersonic aerodynamic study programs are furnishing data on platform, surface cross-section, over-all configuration, boundary layer conditions and aeroelasticity.

Current research programs in the field of aerodynamic heating at high Mach numbers and controlled motion in rarified air and under vacuum conditions are showing the way to meeting future threats.

It should be emphasized that although the missile itself is a spectacular instrument of destruction, it cannot function alone. Even after guidance, propulsion and ballistics and structures have been perfected, the missile is inert and unless the without the equipment for transporting, preparing, testing and launching. The same painstaking design, testing, redesign, manufacture, and inspection required for an effective weapon must go into every item of ground equipment. Accomplishments are illustrated by the following examples:

Vehicles. In one system now in an advanced stage of development, the number of vehicles required to launch a missile has been reduced by 60%, as compared with the system it supersedes. The corresponding weight reduction is even greater. An even more important result is the reduction of approximately 60% in trained manpower requirements.

Propellant Handling. In several of the older systems, highly corrosive, toxic and inflammable propellants constituted a major problem. In many instances these have been replaced by solid type propellants which require little special equipment and fewer men for handling. This, of course, makes possible a faster rate of assembly and handling, with a corresponding improvement in firing rate.

Launchers. The complexity and reloading time of launching equipment is being reduced. In some instances automatic control is replacing manual operations. Extensive investigations of blast effects and launcher tie-down requirements have been made. These have included tests to determine the most effective deflector configurations and the optimum deflection angle.

Some of the more recent designs of blast deflectors use aluminum to reduce weight. In order to reduce launcher tie-down problems, the reactive forces of the exhaust gases have been employed for launcher stabilization. As a result these problems have been reduced in newer type launchers. Mobility and the time required for placement of some launchers have been improved.

Pre-flight Checkout Equipment. Methods and equipment for pre-flight checkout have also undergone striking improvements. An early missile system required four manhours for missile checkout and many of the checks required a high degree of judgment.

A later system reduced this to three manhours. Another system has reduced this to two-thirds of a manhour and the checks are all of a go, no-go type which require no interpretation by the operator. One recent guided missile only requires one-twentieth of a manhour for checkout.

Target Simulators. Another important achievement in testing equipment is the newer type programmed target simulator. This is a most imporant accomplishment from the standpoint of economy and reliability. With this type tester a series of commands selected to test the missile's performance capabilities can be recorded on a magnetic tape.

These are fed to the missile control system and the responses are recorded. This type of testing can be used to replace much of that formerly done with target drones. In addition to the money saved by eliminating the need for expensive drones and the trained men involved, other very important advantages result.

Drone tests are not repeatable. When a malfunction occurs in a missile flight against a drone, an attempt to duplicate the test may not result in the same malfunction even though the same defect is present. In the tape-controlled test, the commands can be duplicated any number of times.

The testing of missile capabilities must obviously be limited to the ability of existing drones to execute the required maneuvers. Guided missiles must be designed to meet the threat from planes and missiles now under development which will be in the air from four to seven years hence.

The target simulator is the only device available for this type of tests. Also, since the time and money required for this type of test are much less, faster and more complete performance evaluation is possible.

It must be stressed that problems continue to exist and that obsolescence is an ever prevailing specter. But each day under the guidance of the Army weapon systems development agency, the coordinated effort to provide the Army's arsenal with adequate missiles for both offensive and defensive action is continuing apace.

We have made significant progress. The proof is in *Nike-Ajax, Corporal, Honest John*—already in the hands of troops—and in *Nike-Hercules, Hawk, Dart, Lacrosse, Sergeant,* and *Jupiter*—soon to be released. Ground-to-ground, air-to-air, ground-to-air, we have made them all. And they work.★

Rocket Logic in Retrospect

...t the Deacon finished the one-hoss shay.

Now in building of chaises, I tell you what,
There is always *somewhere* a weakest spot,—
In hub, tire, felloe, in spring or thill,
In panel, or crossbar, or floor, or sill,
In screw, bolt, thoroughbrace,—lurking still,
Find it somewhere you must and will,—
Above or below, or within or without,—
And that 's the reason, beyond a doubt,
That a chaise *breaks down*, but does n't *wear out*.

But the Deacon swore (as Deacons do,
With an " I dew vum," or an " I tell *yeou* ")
He would build one shay to beat the taown
'N' the keounty 'n' all the kentry raoun';
It should be so built that it *could n'* break daown:
"Fur," said the Deacon, " 't 's mighty plain
Thut the weakes' place mus' stan' the strain;
'N' the way t' fix it, uz I maintain,
Is only jest
T' make that place uz strong uz the rest."

So the Deacon inquir... the village folk
Where he could find ... oak,
That could n't be sp...

Oliver Wendell Holmes never dreamed of intercontinental missiles or thermal thickets when he penned "The Wonderful One-Hoss Shay". Yet, a hundred years later, no sounder logic exists for the designer of rocket cases. In the ideal rocket design, where a pound less weight can mean miles more distance, all sections should be exactly of identical strength. No part should be one iota stronger or weaker than the rest.

Fulfilling Dr. Holmes' "picture of the impossible" to the ultimate degree has been M. W. Kellogg's aim from the time it began designing and fabricating rocket cases for the Navy Department in 1951. Since then the company has continued to participate in the research, development, and production of a wide range of missile and rocket propulsion systems.

Organizations interested in putting the Kellogg team to work on their specific rocket problems are invited to write.



DEFENSE PRODUCTS DIVISION

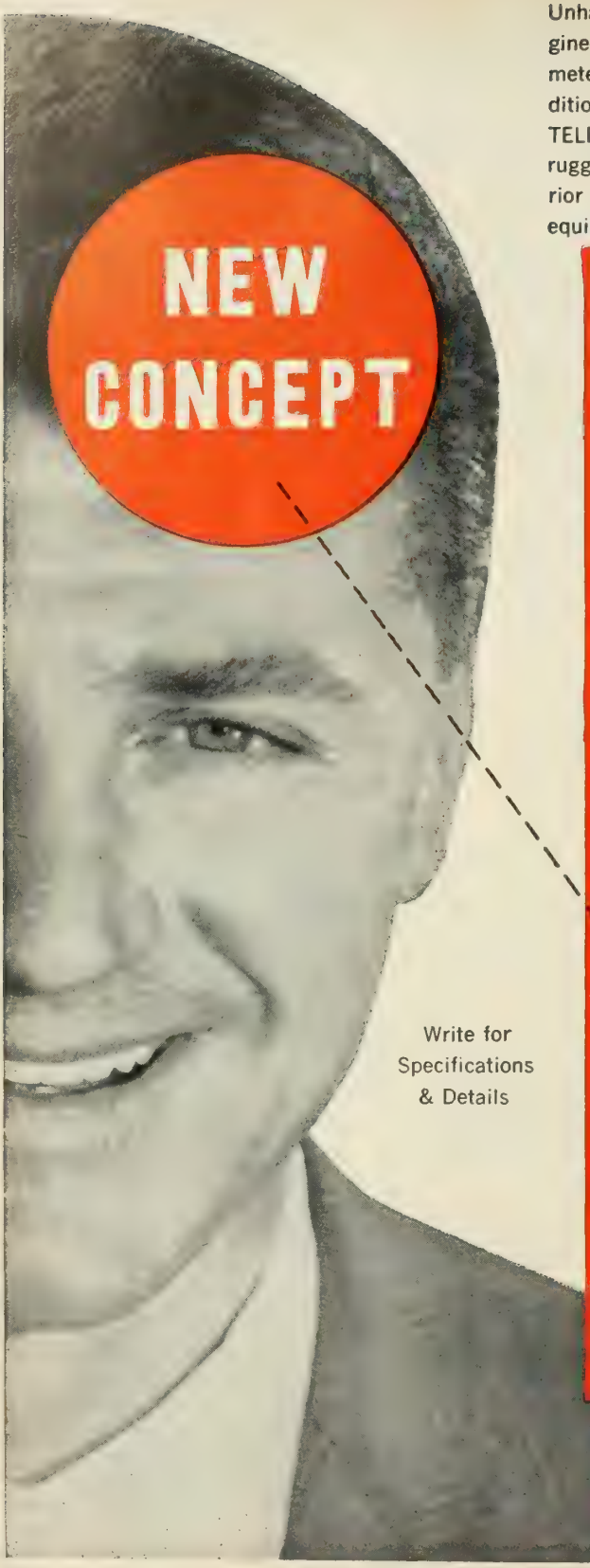
THE M. W. KELLOGG COMPANY

711 THIRD AVENUE, NEW YORK 17, N. Y.

A SUBSIDIARY OF PULLMAN INCORPORATED

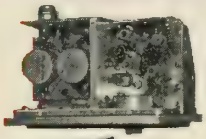
The Canadian Kellogg Company Limited, Toronto • Kellogg International Corporation, London
Companhia Kellogg Brasileira, Rio de Janeiro • Compania Kellogg de Venezuela, Caracas
Kellogg Pan American Corporation, New York • Societe Kellogg, Paris

M KELLOGG W

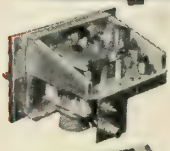


Unhampered by traditional thinking, TELECHROME engineers have developed an entirely new concept in telemetering equipment. Today's new environmental conditions and distances for missiles require new designs. TELECHROME units are unequalled in compactness, ruggedness* and dependability. Because of their superior qualities these highly efficient units are replacing equipment of other manufacture.

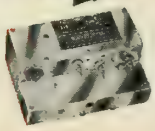
Direct FM Transmitters Crystal controlled 215-235 megacycles. 125kc deviation.



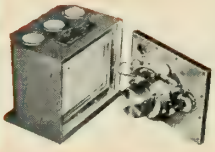
Model 1462—6" x 4¼" x 3¾"
50 to 80 Watts



Model 1463—5 9/32" x
3 13/16" x 4"
15 to 30 Watts



Model 1472—4" x 1.5"
x 2.7"
2 Watts

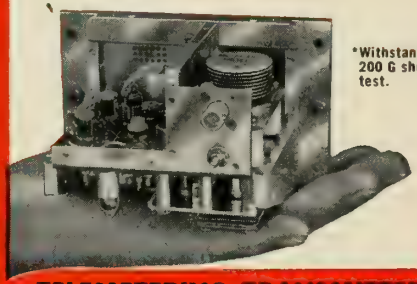


Model 1460—5" x 4⅝" x 3 15/16"
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Upper Air Research Progress . . .

Navy Rockets and the Future of Man

By Rear Admiral Rawson Bennett
Chief of Naval Research

THERE IS ONE unknown that has always been mankind's greatest challenge, and that is the heavens above. Today we simply call it space. We have constantly sought to solve the enigma of heavenly phenomena particularly our own moon, the planet and the stars. And deep within us there has always been the urge to soar through the skies and reach those other worlds.

Soon man will take the first step toward achieving that goal. A man-made sphere will be rocketed 300 miles into the upper atmosphere at a speed of 18,000 miles per hour or nearly five miles per second. This sphere, only 20 inches in diameter, will then circle the earth like a tiny moon while it automatically sends back information to us.

This project is the next logical step forward. The earth satellite heralds a new era in what might be called space research, presaging the day when man himself will venture into outer space.

In 1923, the Naval Research Laboratory was established to carry out broad research in the physical sciences. It is this laboratory, now under ONR management, that is chiefly involved in the development of the earth satellite and launching it into space.

The Office of Naval Research was itself a pioneer organization when it was established in 1946. It was the first military agency specifically designed to support research on a large-scale basis. ONR's chief mission is to finance and promote research by academic and commercial laboratories in virtually every field of science.

Since 1946, ONR's program in upper atmosphere research has been accumulating important scientific data that is achieving both these ends. The knowledge that is being gathered has enabled scientists to gain a better understanding of cosmic-ray activity and very high altitude weather conditions.

If our aircraft are to navigate at heights approaching 100,000 feet at speeds of Mach 5 or more we must have far more accurate information on air density, pressures, and temperatures as well as cosmic radiation at those heights. If we are to achieve any considerable improvement in radio and television communications and long-range electronic detection devices, we must know a great deal more about the ionosphere and magnetic field above the earth which have a controlling effect on radio signals.

The ionosphere is a region of rarified, ionized gas which exists at levels between 50 and 250 miles above the surface of the earth, and our means of studying it from the ground are extremely limited. This complex region of the atmosphere is interrelated with solar activity, geomagnetic disturbances, the aurora, and cosmic rays which are very high-energy-charged particles that come from somewhere in outer space and bombard the earth in all directions.

Each of these phenomena must be studied in relation to the others. For example, magnetic storms that frequently are associated with radio blackouts are connected with sunspots which in some way affect the energy distribution and total flux of cosmic rays.

More precise measurements of the fluctuations in cosmic-ray activity may permit a correlation of these two phenomena. This may ultimately give us the ability to predict periods of poor communication due to solar storms much as weather is predicted today.

The upper atmosphere holds the keys to many of the basic secrets of the universe, yet until the advent of the high-altitude sounding rocket it was like a rolled up scroll that gave us only intriguing peeks and glimpses of its contents.

The first rockets used in upper atmosphere research by the Navy and others were the German V-2's, of which more than a hundred were available after World War II. Most of the V-2's hit altitudes of about 100 miles with one reaching 117 miles.

Convinced by the experience with the V-2 that there were immense possibilities in the use of research rockets, the Navy in 1946 became the first to order rockets specifically designed for upper atmosphere research. That year the Office of Naval Research in close cooperation with the Navy's Bureau of Ordinance ordered the *Aerobee*, which was designed and developed by the Applied Research Laboratory of Johns Hopkins University and the Aerojet-General Corp.

The first full firing was made in November, 1947. Later it was somewhat modified to become the *Aerobee-Hi*. It has been in continuous use longer than any other research rocket and will be one of the chief rockets used in the upper atmosphere experiments of the International Geophysical Year.

Both the *Aerobee* and the *Aerobee-Hi* are much smaller than the V-2 —about 23 and a half feet long and 15 inches in diameter, with the *Aerobee-Hi* generating a thrust of 4,000 pounds. Yet this Navy rocket has been able to travel considerably higher and faster than the V-2, recently reaching a record altitude of higher than 180 miles (possibly 190 miles).

In 1946 ONR's Naval Research Laboratory ordered the large *Viking* research rockets which would be able to carry payloads approaching the 1,000 pounds of the V-2. Developed by The Martin Co., the *Viking* was 48 feet long but reduced to 42 feet in later models. The 14th and last of these rockets was recently fired.

The diameter of the first series was two feet, eight inches, later in-

creased to four feet for the second series. The 8,000 pound fuel load consisted of liquid oxygen and ethyl alcohol, generating a thrust of about 20,000 pounds, far less than the V-2, but the weight of the *Viking* was also considerably under the V-2, ranging from 10,000 to about 16,000 pounds.

The *Viking* rockets, carrying payloads some of which were only 100 or 200 pounds less than the V-2, consistently reached far higher altitudes than the V-2 and in 1954 established the record for single-stage rockets with a height of 158 miles. Although this record has been recently broken by the *Aerobee-Hi*, the payload of the latter rocket is only a few hundred pounds as compared to 825 pounds for the record-breaking *Viking*.

Both the *Aerobee* and the *Aerobee-Hi*, which was first fired in 1952, are "boosted" rockets, in which a JATO-type solid-propellant booster assists the rocket at the start of its flight and then falls away after about three seconds. The fuel is alcohol-aniline and nitric acid which sends the rocket at speed faster than 4,000 mph.

Some of the instruments carried in its nose cone measure the rocket's performance, particularly propulsion, aerodynamics and structure. In recent flights the instruments planned for use in the earth satellite have been carried in a section just below the nose cone.

In one recent flight, instrumentation roughly equivalent to the weight of the satellite included two thermistors for measuring temperatures within the instrument section, a differential pressure gage for comparing internal and external temperatures, three micrometeorite microphones, a solar aspect cell, a Lyman-alpha ion chamber, a satellite Minitrack telemetering transmitter, and the necessary power for the transmitter.

A photoelectric cell was mounted on the side of the rocket to determine the aspect or vertical position of the rocket with respect to the horizon. A solar battery, which weighs considerably less than the mercury-cell battery that will power the transmitter in the first satellites, was also flown to determine its suitability as a power source for the satellite.

Scientific data obtained by the satellite package were telemetered back to earth during the flight via the Minitrack system, while rocket performance data were telemetered by the more conventional *Aerobee* system. The micrometeorite microphones, just as they will on the satellite, detected the sounds of micrometeors or "meteor dust" hitting the skin of the rocket.

One of the phases of the Naval Research Laboratory's rocket research program is high-altitude photography. The first reasonably good high altitude photographs were obtained on a V-2 rocket flight in April, 1947. Little improvement in definition or altitude was achieved until the 1954 record-breaking flight of the eleventh *Viking* previously mentioned.

The 158 miles reached by this rocket is the greatest height from which photographs of the earth have ever been taken. The pictures were made with a 4 x 5-inch K-25 aircraft camera. Sheet-metal housings for the camera were used in the earlier flights but these frequently opened on impact and the film was exposed. Recovery became satisfactory when it was decided to wind the film into a steel casette.

One of the basic problems in rocket research in the upper atmosphere is the expense. The *Aerobee-Hi* rockets, which cost less than the *Viking*, run between $30,000 and $40,000 per rocket. Partly for this reason the Navy has sponsored the development of smaller rockets that are launched from balloons or aircraft.

The balloon-rocket method, known as the *Rockoon*, was developed by Iowa State University. This method combines the 12-foot solid-propellant *Deacon* rocket produced by the Allegheny Ballistics Laboratory with the high-altitude plastic *Skyhook* balloon, which lifts the rocket at a speed of about 800 feet per minute to altitudes generally ranging from 50,000 to 70,000 feet.

At a fixed altitude a pressure switch in the firing gondola closes, setting off the igniter inside the rocket and firing it in an almost vertical direction. The rocket burns for approximately two seconds, but with the aerodynamic drag of the lower altitudes eliminated this is sufficient to send the rocket to altitudes of 50 miles or more.

Another method known as *Rockair* uses aircraft which are sent up to altitudes of 40,000 to 50,000 feet, at which point rockets capable of reaching heights of about 100 miles can be launched.

The nose cone of the *Deacon* rocket contains a small FM transmitter, which telemeters signals from a geiger counter, ionization chamber or pressure and temperature instruments.

The radio signal is received on the ground station where the detector signal is unscrambled from the FM carrier. This signal is then amplified and recorded by a Brush recorder on a moving strip of paper. This makes it possible to determine the cosmic-ray intensity or temperature, pressure and density at any time during the flight.

During the IGY the Navy will play a prominent role in gathering information on the upper atmosphere both through the earth satellite program and through exploration with a number of *Aerobee-Hi* and *Rockoon* and *Rockair* rockets. Most of the *Aerobee-Hi* rockets will be launched from Fort Churchill, Canada, which is on the edge of the northern auroral zone.

This research will be directed especially to the aurora and to the ionosphere and solar radiations in the auroral zone. The *Rockoon* combinations, to be launched from ships in the Pacific, will be used in getting data on solar ultra-violet and X-ray emissions during solar flares.

There are many unknowns that must be known before we can seriously consider space travel. If the duration of the flight is long, the effects of cosmic and solar radiations on humans must be determined, and we are only beginning to study their effect on living cells. Another risk difficult to assess at present is the probability of meteor collisions.

Although this hazard has been estimated and various schemes proposed for eliminating it, none have ever been tested. In a long flight elaborate equipment requiring a continuous power source will be necessary to provide the human passengers with the necessities of life. This equipment, along with that needed for the navigation of the vehicle, will have to be completely automatic and reliable because the long flight would probably impose terrific physical and psychological strains on the passenger.

These and other serious obstacles can be overcome only by a relentless program of basic research. We have yet to fully understand the theory of combustion in a rocket motor. We need more research on fuels, on high-temperature metals and ceramics and on new methods for cooling the inner walls of rocket motors and the outer skins of high speed airframes.

The most direct way to attack such problems is through the development of more and better sounding rockets that can ascend far above the altitudes thus far reached. The achievement of practical, reliable, unmanned satellites is also essential.

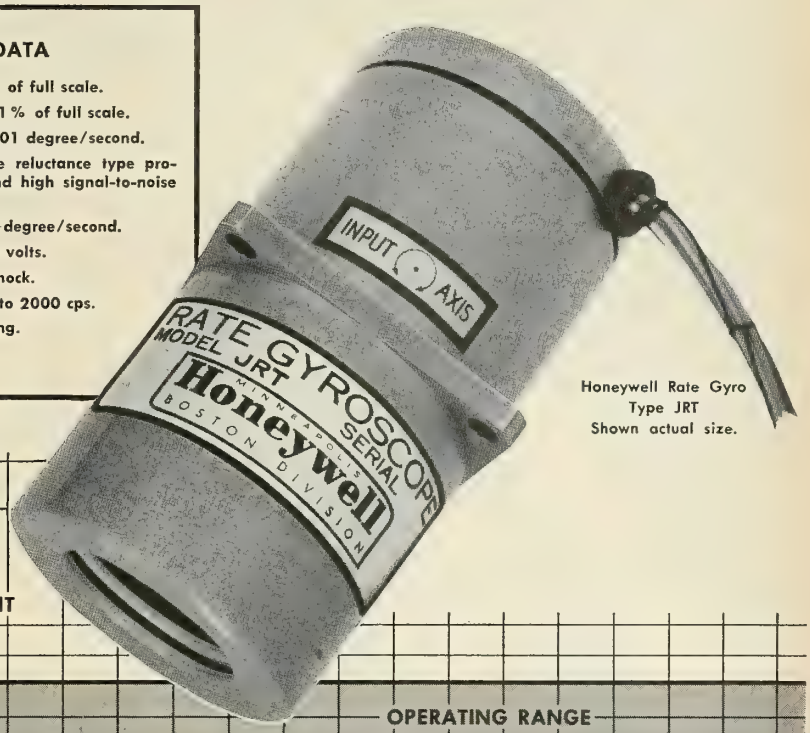
Rockets and satellites are our best laboratories for space flight research. They are undoubtedly the predecessors of future space ships.

Although space may eventually be a future field of battle, it is a narrow view to consider rocket research as largely military in nature. It would be equally shortsighted to dwell primarily on the material benefits that might be derived from exploring other planets. The one product that makes the entire program justifiable and undeniably worthwhile is knowledge. It is the same product that characterizes all basic research.★

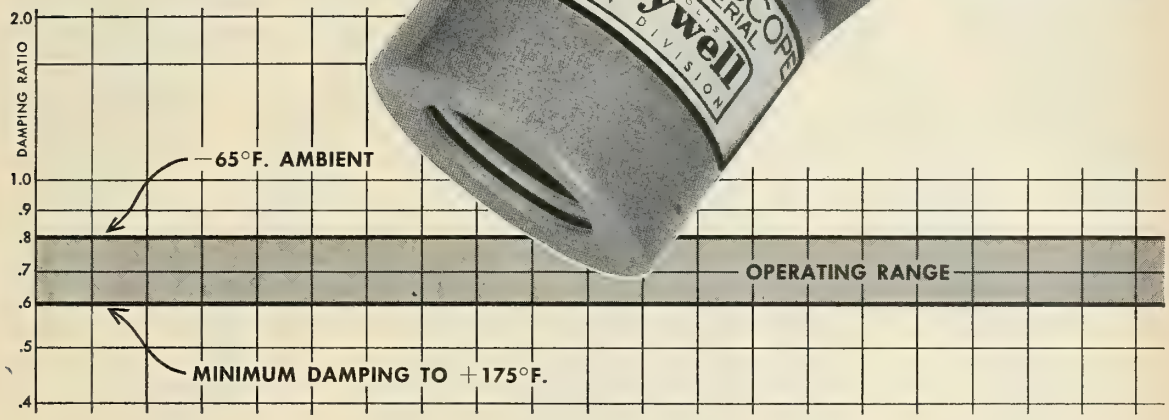
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By Rear Admiral John E. Clark U.S.N.

Director, Guided Missiles Division

Office, Chief of Naval Operations



Navy Missile Progress:

Death of the Big Gun

THE NAVY'S INITIAL missile effort was directed towards basic research. Early work included firing the *Aerobee* and *Viking* rocket series to obtain cosmic radiation data from very high altitudes. Other work tested new ideas and approaches to specific problems such as the feasibility of firing a supersonic missile and controlling it during flight.

One of the earliest missile programs was initiated in 1945 by the Bureau of Ordnance to develop a surface-to-air guided missile. The contract for the research and development of this project was awarded to the Johns Hopkins Applied Physics Laboratory and assigned the now famous code name *Bumblebee.*

The Applied Physics Laboratory was staffed with an outstanding group of scientists and engineers who had done a great deal towards the wartime development of the VT fuze. Their *Bumblebee* program has made great progress and is responsible for the development of all of the Navy's current surface-to-air missiles. Research was also undertaken to develop missiles in the air-to-air, air-to-surface, and surface-to-surface categories.

The *Bat,* an active homing glide bomb, was developed by the Bureau of Ordnance in cooperation with the Bureau of Standards and sank several Japanese ships at the end of World War II. It carried a small radar in the nose which was given a target by the pilot in the mother aircraft prior to launch.

Once launched, the *Bat* homed on its target without further assistance, allowing the aircraft to maneuver as desired. Although successful, *Bat's* short range and slow speed soon put it in the obsolete category.

Another early missile was the *Lark* developed by the Bureau of Aeronautics and Fairchild Aircraft Corp. to prove the feasibility of certain homing techniques. The *Lark* was surface launched and flew at subsonic speeds. It was quite successful and in 1950 knocked down an F6F drone with a direct hit.

This was the first example of what has become an ever-increasing Navy problem, namely that guided missiles have such small miss distances that they frequently splash the expensive drones even without using a warhead.

In the surface-to-surface category, the Bureau of Aeronautics redesigned the German V-1 Buzz Bomb for firing from a submarine, the *USS Cusk.* The *Loon,* as it was called, pioneered a command guidance system, explored the possibilities of pulse-jet propulsion, and gave the Fleet practical experience in developing defenses against guided missile attack. This was also the first time a missile was fired from a submarine by Fleet personnel.

The build up was commenced at such facilities as the Naval Ordnance Test Station, China Lake (Inyokern) Calif.; the Naval Air Missile Test Center, Pt. Mugu, Calif.; the Naval Aviation Ordnance Test Station, Chincoteague, Va.; and the Naval Ordnance Missile Test Facility, White Sands Proving Ground, N.M.

Many now have extensive laboratories and engineering staffs and have made numerous contributions to the solution of such problems as telemetering, flight data reduction, drone control, and miss distance measurement techniques. At least one has been responsible for conceiving and designing an entire new missile system.

For shipboard testing, the Navy converted the 15,000 ton seaplane tender *USS Norton Sound* to handle missiles. To date, she has fired a variety of missiles that would rival the record of any shore facility. These include *Loon, Lark, Aerobee, Viking, Regulus,* and *Terrier.*

Later, in 1952, when the *Terrier* program needed extensive shipboard testing and evaluation, the old 35,000 ton battleship *Mississippi* was given a *Terrier* battery aft. The "Old Miss" has since gone to the scrap pile but before she did the *Terrier* became "the new Fleet weapon."

Early R&D missiles were handmade by scientists and engineers at nearly prohibitive costs. These were R&D missiles and frequently bore little resemblance to the final production weapon. Operability prior to a particular firing was established by a team of scientists and engineers that gave the missile a most rigorous check-out.

The team members were frequently the same personnel who built the bird. These procedures were necessary with the state of the art at the time but out of the question for a service shipboard missile. A great deal of improvement would have to be made in this area. The missiles would have to be reliable and rugged over a tremendous range of service conditions and yet be maintained by relatively untrained enlisted personnel.

Another lesson learned was the advantage of the "weapon system" concept. In this approach responsibility for the entire system's design is vested in one central activity. Coordination of design can be much more closely controlled and the function and importance of a given part can be kept in proper proportion. This is particularly important when a unit is under development and frequent design and production changes are the order of the day.

Related to this approach is the assignment of contractor responsibility. Formerly contracts were let by the technical bureaus for each piece of a system. The complexity of a guided missile system and the necessity of designing each piece to maxi-



High over the Mojave desert, a Sidewinder missile is fired from a Navy jet fighter and streaks through the air for a kill against a target drone. Sidewinder is one of the most potent weapons in current use. Future versions will employ infra-red self-homing guidance.

mize system performance led to the development of two new types of contractual agreements. In one, a designing agency is selected to be responsible for the R&D and basic design.

Other firms are then selected to be the production contractors for the pieces of the system using the basic designs given them. The designing firm remains responsible for the overall system design and coordination but the production contractor is responsible for his hardware.

In the other type of agreement, one contractor is made responsible for system design, coordination and production. He sub-contracts but is still responsible for the finished product. Both techniques have their place and the selection is usually based upon the complexity of the system and the individual capabilities and organizations of the contractors.

Developing a missile from the R&D stage to shipboard service normally starts with a series of test vehicle flights to prove out the basic ideas. When this is completed and the necessary design changes made, a series of prototype missiles are fired. These are hopefully similar to the final product and are the first test of the complete missile system.

Upon successful completion of this phase, a test of the first production pilot line missiles is commenced. This is supposed to work out the bugs so that the production line version is reliable. Lastly, the production line missile is evaluated and released to the Fleet. During this whole time problems arise and have to be solved.

The missile might be exposed to icing conditions in the North Atlantic or to temperatures above 100° in the South Pacific. In one case the wing controls and launcher shoes must be kept operable despite ice formation. In the other, the missile electronics must be able to stand long periods with warm up power applied without overheating from the combined effects of sun and internally generated heat.

The missile must be able to withstand the continuous vibration of a ship yet be so sensitive in flight that it can detect the slightest acceleration. Missiles must be stowed aboard ship so that they are readily available for action but be safe as possible. Fire, shock, battle damage and inadvertant ignition are hazards of the trade.

What do you do, for example, if a rocket engine goes propulsive in a magazine? How do you store a volatile inflammable like av-gas in a submerged submarine full of electrical equipment with sailors who like an occasional smoke? These problems have to be solved before the missile can be accepted for service use.

Another thorny problem area is missile reliability and check-out. How do you produce a missile which has thousands of components yet is always ready to go when you want it? It has been found that one way to lick this is to allow the production contractor to start his production engineering and reliability work as early in the program as possible, preferably in the test vehicle stage. This gives him time to work out the bugs before his designs are finalized.

A good test and maintenance philosophy is required. What components should be tested in the field, how often should they be tested and, if a component fails, what level of repair and replacement should be used? These are extremely important questions affecting not only the missile and the test equipment but such areas as logistics and training as well.

Our present thinking is to have test equipment which tests the missile components known to have a relatively high failure rate or whose function is particularly important. This is a "go-no-go" test and pinpoints a fault only to a replacement level.

Then a package replacement is made and the faulty package is turned in for repair to a depot. The degree to which the package replacement is carried depends upon many factors such as reliability, test equipment simplification, cost and ease of maintenance.

In these days of fantastic budgets missile costs have to be reduced. This problem is attacked across-the-board. Designs are examined for producibility and component economy. Standard "shelf" items are used where performance isn't penalized.

Interchangeability of parts between missiles or components within a missile help to increase production and cut down unit cost. Logistics are thoroughly investigated and planned to increase efficiency and cut costs.

Missile transportation from factory to dockside has to be worked out carefully. The possibility of high explosives detonating in public transportation has to be minimized, yet speed of delivery is important. Missiles in transit are unavailable and this effectively means buying more missiles. Will the missile fit in the conveyor, can it be handled by the equipment available at the transfer points, will handling damage the missile? These and other questions must be answered.

Consideration must be given to the training of personnel so that at the time of a missile release adequately trained personnel are available. To do this schools and courses are set up, usually during the final stages of the missile R&D. Sometimes courses are conducted at one of the Navy's training centers such as the Fleet Air Defense Training Center at Dam Neck, Virginia.

In other situations a school may be set up right at the contractor's plant. Naval "Guided Missile Units" are set up to assist in the R&D flight testing and provide a trained manpower pool for future expansion. GMU-21, for example, did the shipboard testing of *Terrier* in the *USS Mississippi* and then provided a nucleus of trained personnel for the first missile cruisers, *USS Boston* and *USS Canberra.*

The Bluejackets have now taken over from the scientists and engineers and missiles are handled aboard ship entirely by Naval personnel. Reliability has improved if anything and the Bluejackets have shown that they are fully capable of maintaining and operating their new weapons.

These are a few of the problems along the road of developing service guided missiles.★

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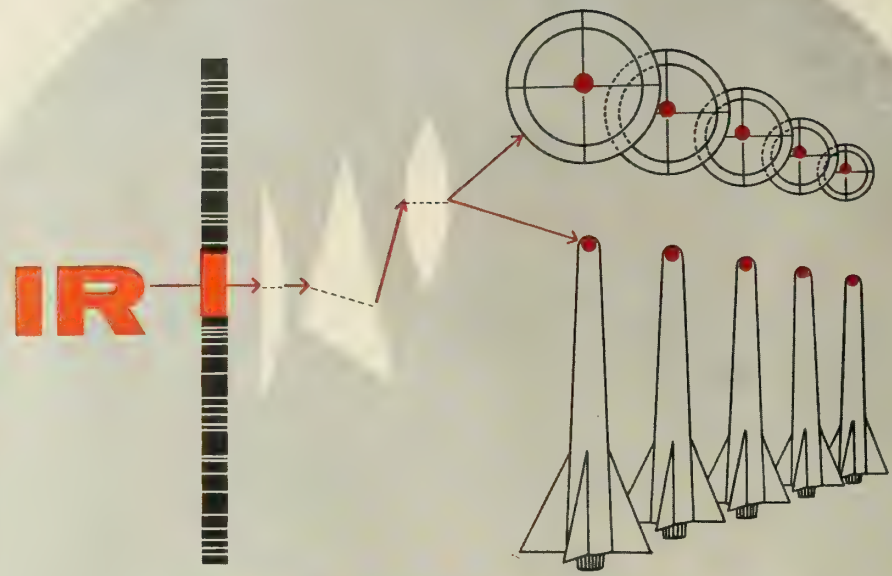
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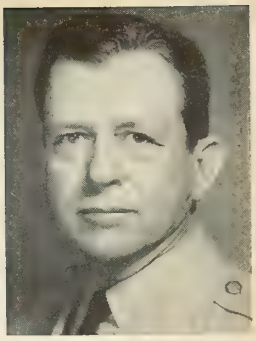
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Progress in Air Force Scientific Research



By Brig. Gen. Hollingsworth F. Gregory, USAF
Commander, Office of Scientific Research (ARDC)

ALL STRATEGIC and tactical military planning is evolved from an "estimate of the situation." This can be prepared only on the basis of the most complete knowledge possible of friendly and enemy weapon capabilities and the factors of personnel, material, communications, terrain and weather. The fighting man puts weapon capability, terrain and weather at the top of his estimate.

It is important for the airman to have full knowledge of his theater of operations—the atmosphere and the space around it—as it is for the infantry to know the surface of the earth. He must be acquainted with every aspect of the atmosphere or space, its environment, our own and the potential enemy's capabilities. This includes vehicles, weapon systems and closely related human factors.

We must adapt the old infantry rule to the aerial dimension: "Take the high ground."

Elevation is as important to the airman as it has ever been to the rifle-bearing soldier. There is no aspect of space which can be ignored if we are to obtain intelligence essential for domination of this future theater of operations.

The weapons and vehicles of this theater demand an exploratory effort equal to that of the new environment itself. Exploration is of value only as its findings are correctly interpreted and usefully related to solving the military problems at hand.

The mission of the Air Force Office of Scientific Research, an agency of the Air Research and Development Command, is the encouragement of exploratory effort, the understanding of its results and the utilization of its findings for the present and future needs of the Air Force. AFOSR's contribution to the estimate of our present defense situation and future potential helps the Air Force maintain a dominant position on the "high ground."

Our method of operation includes making our mission known to research sources, examining their lines of investigation and providing whatever support and guidance they may need.

To accomplish this we seek help from our academic and industrial laboratories. AFOSR and its military and civilian personnel are charged with the sole task of recognizing the military implications of this work and supporting with funds, tools, procurement methods and communication, those persons who can supply us with the essential ingredients for our changing estimate of the situation.

Materials are our initial problem. Recent breakthroughs in propulsion technology have presented us with rigorous new parameters imposed by higher altitudes, the thermal barrier, accelerated corrosion, protection from radiation and stresses due to ever-increasing performance requirements.

An AFOSR-sponsored study with great promise is under way at the Institute of Engineering Research of the University of California. Because upper temperature limits of commercially available metals are approximately 1700°F., investigators at this university proposed a study to improve the ductility of refractory ceramics.

Stimulated by Joffee's disclosure in 1924 that normally brittle crystals of sodium chloride become ductile and deformed when immersed in warm water, the investigators recently attempted similar work with crystals of potassium chloride and silver chloride. These investigations showed promise and have received our support.

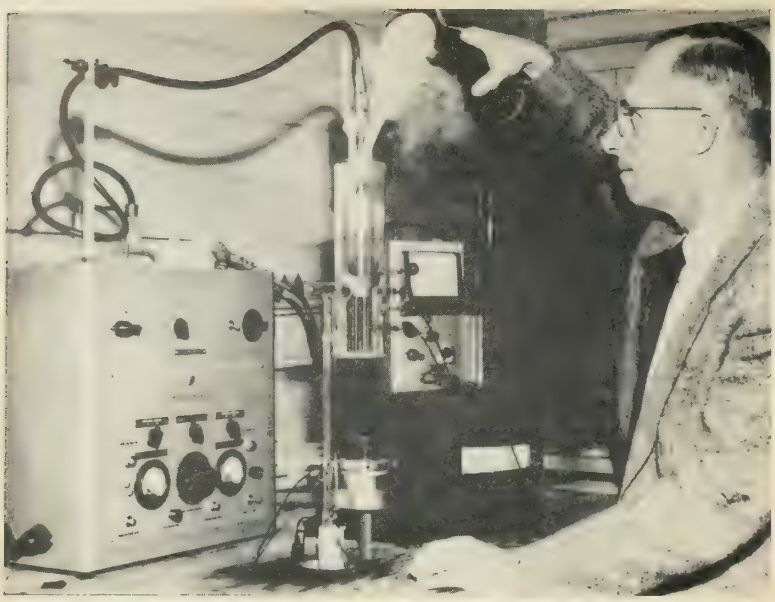
The cost of this program is less than that of three conventional 2½-ton military trucks. AFOSR's recognition of its implications may save countless millions in future airframe and powerplant development.

Our future fighting vehicle undoubtedly will traverse the highest regions of the atmosphere, where it will be subjected to constant bombardment by intense ultraviolet radiation. Knowledge of the reaction of light metal shells to this radiation is important. Recognition of this stimulated AFOSR's interest in the work of Drs. H. Margenau at Yale and B. Henke at Pomona College. They are both investigating the absorbtivity and emissivity of metals over the wave length of 10 to 1000 angstrom units.

The reaction of light metal shells to the extreme ultraviolet and soft x-ray regions is a special area of AFOSR interest. Incident radiation is an important factor governing the equilibrium of missile skin temperature. Indications are that certain light metals and alloys, by exposure to selected wavelengths, may give enhanced absorption properties.

Many materials for Air Force application may evolve from studies under way at the University of Florida. A group under Dr. George E. Butler is tracking down new methods and answers to the problems of polymerization. Substituting silicon, phosphorus, selenium, germanium, zinc, or sulphur for nitrogen in allyl-derived polymer may yield new high-temperature materials. Among these are nonflammable lubricants, antioxidants, and new types of oil-resistant synthetic rubber.

When metal foil is bombarded on one side by positive ions, it ejects metallic atoms from the other side. This phenomenon, discovered by Dr. L. G. Parratt of Cornell University under an AFOSR contract, may provide



Dr. Erwin W. Muller, Pennsylvania State University Physics Professor pours the cooling agent into his field ion emission microscope for photographing single atoms.

new methods of mass spectrometry which will greatly enhance techniques employed in the analysis of solids.

The work described here is a very small representation of AFOSR's total effort in this area. The importance of this knowledge to a valid estimate of our technological situation cannot be stressed too heavily.

The performance of a vehicle and its potency are largely governed by its propulsion system. Many AFOSR contracts aim for a major breakthrough in this field.

Since the early development of liquid-fuel rockets, extensive research effort has been devoted to the evaluation of various fuel and oxidizer combinations BMW (Bavarischen Motor Werke), for example, evaluated some 3,000 fuel-oxidizer combinations for the Germans during the Second World War. AFOSR contractors are studying conventional fuels, and hoping to obtain a better understanding of the combustion process.

AFOSR work in propulsion involves many vital areas of investigation. Three can be mentioned here: studies of ultra-energy fuels, solid propellants and flame speeds. The problem of propelling vehicles longer distances at higher altitudes involves fuels with higher specific impulse than current, conventional, chemical compounds.

Aerojet General Corp., under AFOSR contract, is investigating the use of free radicals and atoms to augment burning rate and thrust. It has been discovered that stable molecular particles can be made to dissociate into free radicals if enough energy is introduced from an external source to break their chemical bond.

When the recombination of these particles occurs, the energy release is tremendous. The bulk of U.S. free-radical research is now being carried out at the National Bureau of Standards under a tri-service contract. However, AFOSR had sponsored some of the initial investigation in this field.

Studies of flame speeds must necessarily accompany investigation of propulsion methods. AFOSR has a number of contracts involving flame speeds. The fact that turbulent flames have higher speeds than laminar flames has been established, but as yet attempts to correlate speed with the intensity of the turbulence have been only partially successful.

Research efforts at the Bureau of Mines have disclosed an important anomaly: Indications are that turbulence intensity accounts for the increased flame speed at Reynolds Numbers of 50,000 to 100,000, but not for increased speed at lower numbers.

Investigation disclosed that flame speeds had a maximum value close to 25,000 rather than an increased speed in direct proportion to the increase in intensity. Flame-speed studies are becoming increasingly important as attempts are made to achieve better yardsticks for the measurement of the combustion processes.

Research has given us two new devices which have application as spectrometers, amplifiers, or oscillators. They were by-products of recent molecular and nuclear investigations sponsored jointly by AFOSR, the Office of Naval Research, and the Signal Corps Engineering Laboratory, and are known as the solid-state maser and gas maser. (Maser is short for microwave amplification by stimulated emission of radiation.)

These devices have military applicability almost as widespread as that of the transistor, but they will not compete with the transistor in use. The solid-state maser may give us (1) a low-noise variable microwave amplifier, (2) an extremely sensitive device for long-range radar detection, (3) better components for a long-range celestial navigation device, and (4) more accurate missile-guidance and weapon-firing systems.

The gas maser promises to yield extremely accurate frequency standards which means an accurate clock for use in electronic navigation and guidance systems. In addition it will make possible a better device for reducing data obtained by use of photoelectric cells.

The principle of the solid-state maser was evolved by Dr. N. Bloembergen at Harvard University. Hycon Eastern is now applying it to some of its weapons-development programs. The gas maser was brought about by the work of Dr. C. H. Townes at Columbia University. It is currently being applied to the development of improved long-range navigation systems by Rome Air Development Center.

A project promising considerable new information about the ionization density in far outer atmosphere and the way in which very low frequency electromagnetic waves are propagated at some 20,000 miles above the earth is now underway. Dr. R. A. Hellwell is investigating the "whistler" mode of propagation, at Stanford University under AFOSR contract.

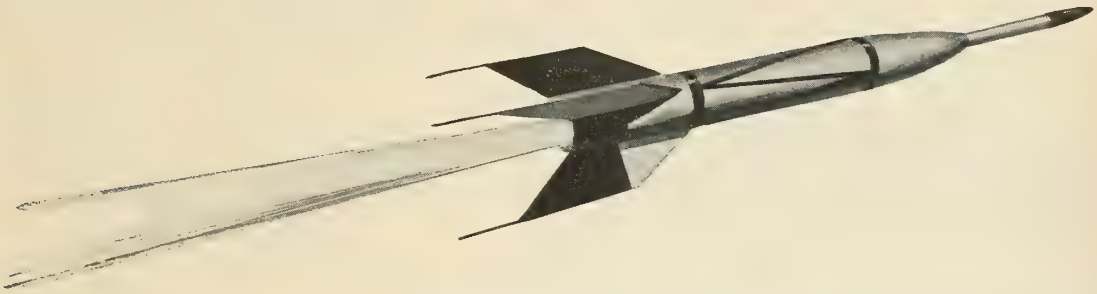
The "whistler" is an atmospheric disturbance in the audio-frequency range resulting from lightning discharge. If sufficient ionization is present some of the energy of the discharge will be guided along a line of the earth's magnetic field through the ionosphere and far into space, returning to the earth as a dispersed wave train at the other end of the magnetic field line.

It has been demonstrated by the transmission of manmade signals between Annapolis and Cape Horn (approximate conjugate points of an earth's magnetic field line), that the "whistler" mode of propagation is real and can be used for communication and guidance systems. This research may uncover new possibilities for vehicles traveling far out from earth.

The "whistler" also offers a new "probe" into the properties of the outer atmosphere, notably the variation of

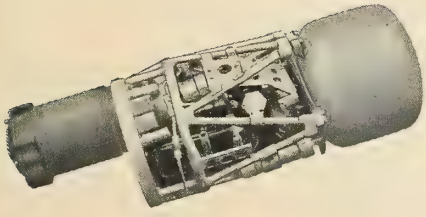


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ambient ionization density with distance and the existence of the "ring current" which should be found between 25,000 and 35,000 miles from the earth.

This research will provide information on ionospheric irregularities, velocities of solar streams entering the atmosphere and perturbation of the earth's magnetic field, thus providing a better theoretical interpretation of magnetic storms and aurorae, both of which strongly affect communication and guidance.

Obtaining accurate estimates of future propulsion, materials and guidance and communications characteristics of our future weapon implies a complete study of its aerodynamic characteristics. To gain this knowledge, AFOSR is sponsoring work of great importance in rarefied gas dynamics.

In addition to the results of the basic work in this field, much has been developed in new equipment for better study and understanding of related problems.

A major breakthrough occurred under an AFOSR contract with the Cornell Aeronautical Laboratory. This was development of a shock tube, a facility for realistic testing of configurations in an air-flow of 10,000 mph and at temperatures of 9000°F for longer periods of time than previously had been possible.

This facility incorporates a "wave superheater," a new departure which increases the length of time an object in the tube is exposed to the heat and pressure of the shock wave. This factor of prolonged exposure permits more sustained and closer observation of the effects of heat and hypersonic flow around objects placed in the tube.

Further valuable knowledge concerning the field of high temperature will be forthcoming as a result of the record-breaking achievements of Dr. A. V. Grosse, at the Research Institute of Temple University, in Philadelphia.

Dr. Grosse's group, working under an AFOSR contract, has succeeded in mixing cyanogen and oxygen to achieve a temperature of 4500°C. By mixing carbon subnitride and oxygen, this group has attained a temperature of 5000°C. Dr. Grosse and his staff have also produced a flame from pure ozone.

With the exception of a small region near the nose, modern high-performance aircraft flying at high speeds are confronted with boundary-layer turbulence. Results of an AFOSR-sponsored study of the interaction of shock waves with turbulent boundary layers have been applied to design of better diffusers, closer predictions of control effectiveness, predictions of separation on supersonic wings and bodies and improved design criteria for the flow passages in supersonic compressors. The past year's work has resulted in the first complete series of tests covering a range of Mach numbers 1 to 4.

Further work toward defining the laws of aerodynamics is sponsored jointly by AFOSR and ONR at the University of Southern California. Results of this work now indicate that skin friction is a much higher factor than existing theories had indicated.

An estimate of the capabilities of our space weapon system would be hopelessly inadequate if we were to ignore the human factors involved. If our vehicle is man-carrying, it must be maintained by men who must be selected, trained and motivated to utilize our system to full advantage in combat.

Whether temporary oxygen deprivation produces reversible or irreversible changes in living tissue is knowledge essential to man's safe existence in a synthetic environment. The Pharmacological Institute of Heidelberg University, sponsored by AFOSR under contract to ARDC's European Office, is investigating this area.

In studying the biochemical changes in brain tissue under low oxygen conditions, attention was concentrated on the phosphate esters which are important in metabolism.

Preliminary experiments on human red blood cells revealed for the first time that anoxia does not change their energy-rich phosphate content. Studies of brain changes produced different results.

Techniques developed by these investigations now make it possible to document all changes in the important compounds in brain tissue whether caused by lack of oxygen or drugs. Research is under way to determine if available chemicals will increase resistance to these damaging effects of oxygen lack.

The Astronautics Symposium held at San Diego last February by AFOSR and the Convair Division of General Dynamics Corp. highlighted the interest and rapid advance in the science of flight.

More than 60 scientists gave papers on various aspects of astronautics, covering such areas as re-entry, tracking and communications, environment and measurements, propulsion, orbits and human factors. The open sessions were followed by a one-day classified session which was highlighted by a talk on "The Military Requirements for Manned Space Vehicles" by Colonel W. O. Davis, AFOSR Deputy Commander for Operations. Over 550 clearances were obtained for this session.

Total symposium registration was over 700. All major press, radio, and television organizations were represented, and the meeting received excellent coverage by all media.

It is clearly recognized today that military success is born of plans conceived by what is known as the indirect strategic concept. Direct strategic concepts are those plans which are evolved primarily to offset known enemy capabilities or intentions.

The indirect approach is predicted on plans evolved from complete knowledge, understanding, and application of our own techniques and weapons, largely independent of hostile influences to our thinking. The few examples of research work mentioned here are a random selection from the more than 600 basic research contracts supported at this time by the AFOSR.★

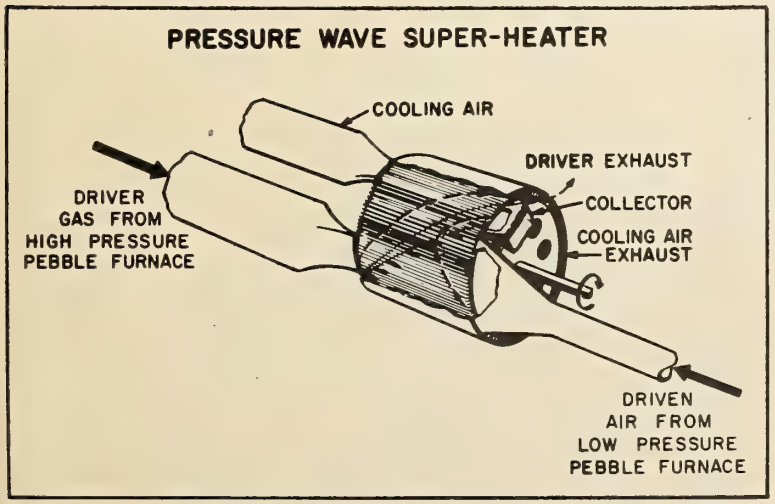


Diagram of a pressure wave super-heater such as that employed to extend the period of test conditions in a shock tube. This is typical of AFOSR-supported research programs.

TECHNIQUES and DEVELOPMENTS
in oscillographic recording

FROM
SANBORN

DESIGN PRINCIPLES AND SOME APPLICATIONS OF A PREAMPLIFIER FOR LOGARITHMIC MEASUREMENTS

THE Model 150-1400 Log Audio Preamplifier (Figure 1), one of eleven plug-in "front ends" now available for 150 Series systems, permits measurements involving logarithmic or exponential functions. The "Log Diode" circuit (shaded portion of circuit block diagram in Fig. 2) is the heart of this instrument, and is based on the logarithmic relationship between the voltage across a thermionic diode and the current through it. If R is large, the current through the diode i_1 becomes proportional to the voltage e_1, and the logarithmic relationship of e_2 and i_1 is transformed into a logarithmic relationship between e_2 and e_1. Circuit constants for this Preamp were chosen to provide an accurately logarithmic relationship between e_2 and e_1, over the range of 200 to .63 volts for e_1. This is a 50 db spread, and the gain of the DC output amplifier (fed by e_2) is arranged so that a 50 db variation in e_1 produces a 50 mm stylus deflection.

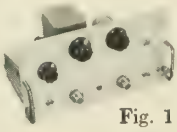


Fig. 1

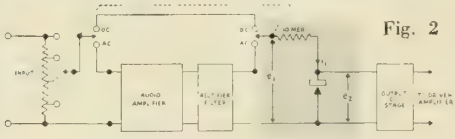


Fig. 2

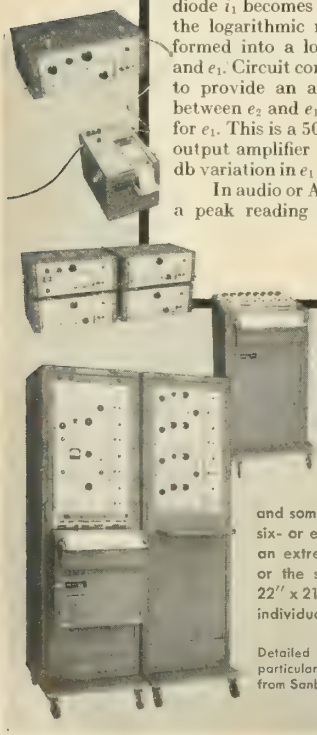
In audio or AC measurements, e_1 is derived from a peak reading type rectifier-filter circuit, which follows a high quality 20 cycle — 20 KC audio amplifier. With an input of 100 mv RMS, this amplifier will produce a 200 volt output from the rectifier. The 50 db chart, therefore, corresponds to a variation in AC input voltage of 0.316 to 100 mv.

In DC measurements, the audio amplifier is bypassed and the input applied to the diode circuit. Since the diode itself is a rectifier, used in the forward direction with its cathode near ground, the DC input must be polarized with the high side positive.

One broad area of application for the Log Audio preamplifier is audio level recording. For example, room reverberation time can be measured by recording sound level decay after the sound source is suddenly turned off, the reverberation time considered the period required for a 60 db decay to occur. Another example of audio signal recording is the plotting of frequency response curves of audio equipment such as microphones, filters, loudspeakers, etc. A multi-channel recording system with appropriate filters also makes possible audio spectrum analysis.

A second major type of application of this Preamp is the recording of DC voltages on a db basis. If the signals are small, a chopper can be used to convert DC to AC, thus taking advantage of the Preamplifier's audio amplifier. With an impedance matching transformer added to such an arrangement, the system becomes a logarithmic DC millivoltmeter or logarithmic DC microammeter of extreme sensitivity. Such a device could be used for plotting the volt-ampere characteristic of a germanium diode, which might be very helpful in selecting matched pairs of diodes. Another possibility is plotting the output of a fixed gain radio receiver and linear detector to a db scale, to rapidly record antenna performance data.

A comprehensive discussion of the design and these applications of the Log Audio Preamplifier is contained in an article by Dr. Arthur Miller, Chief Electrical Engineer of Sanborn Company, published in the Sanborn RIGHT ANGLE. Copies are available on request.



Which Oscillographic Recording "PACKAGE" fits your needs?

SANBORN "150's" are housed, basically, in either of two ways: a vertical mobile cabinet, or separate portable cases for amplifier and recorder units. This in itself provides a number of "packaging" possibilities, but the number is greatly increased by various other alternate, and sometimes special, housings. For example, an entire six- or eight-channel recording assembly is available in an extremely compact, mobile cabinet only 45" high; or the same recorder can be portably housed in a 22" x 21" x 23" case. If field use of "150's" is planned, individual units in cases fitted with removable covers and carrying handles, connected by patch cords, may be the best answer. Occasionally only a "special" adaption will meet a specific need.

But *whatever* the "150" oscillographic recording "package" you use, you're assured of basic Sanborn "150" advantages: *inkless* recordings in *true* rectangular coordinates; *1% linearity*, resulting from high torque galvanometers and current-feedback driver amplifiers; *numerous chart speeds*, from 0.25 to 100 mm/sec.; choice of *single to 8-channel* systems, readily adapted to new requirements by plug-in Preamplifiers selected from *11* presently available types.

Detailed information, and assistance with your particular recording problem, is always available from Sanborn engineers.

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Propulsion Engineering



By Alfred J. Zaehringer

RESEARCH LABS OF TWO FIRMS engaged in the high energy fuel program are in for expansion. Olin Mathieson (Buffalo, N. Y.) has a new research lab for defense work. Stauffer Chemical Co. (Richmond, Calif.) is spending several hundred thousand dollars in a major lab addition. American Potash & Chemical is now turning out decaborane at its Henderson, Nev. pilot plant. Capacity: 1 lb/day. Cost: $600-800/lb. Eventual cost under $100/lb.

BORON SPECIALTIES will be produced at a second Callery Chemical plant at Lawrence, Kan. Operational by 1958, the plant will cost some $3-4 million . . . React triethylaluminum, aluminum, and hydrogen at 300 atmospheres pressure and you wind up with ethylaluminum hydride. Ethyl Corp. has made the material which may pay its way as a boron-production intermediate, a fuel, or a fuel-igniter . . . An organic system for production of hydrogen peroxide from anthraquinone has been patented (US 2,791,491) by the English Laporte Chemicals Limited . . . Purdue Research Foundation is working on the production of alpha nitroesters. Propellant use is seen.

FRENCH SEPR FIRM has come up with a line of igniters for non-hypergolic rocket propellants. They use organometallics which ignite on contact with an oxygen-containing oxidant. Materials named are: diethyl aluminum bromide, dimethyl aluminum bromide, ethyl aluminum iodobromide, methyl zinc iodide, and methyl aluminum di-iodide . . . Meanwhile, SNCASE reports that it is using dichromates or permanganates as catalysts in nitric acid oxidant systems. The fuels—mixed amines—as catalyzed with 0.1-5% of iron carbonyl.

HOW MUCH ETHYLENE OXIDE (ETO) is being used as a propellant? US ETO capacity is over ½ million tons/year. Estimates tag propulsion uses at about 10-100 tons/year. At current market prices, this would represent an upper chemical market of about $30,000-$50,000/year. Virtually all ETO goes into APU's for the IRBM and ICBM program.

AMMONIUM PERCHLORATE, smokeless oxidant for composite solid propellants, is now being made on a continuous basis. American Potash & Chemical Co., Henderson, Nev., is turning out about 10 tons/day at the Navy-owned plant. Capacity is 40 tons/day. Since this is the only large-scale US production facility, ammonium perchlorate solid propellants are being produced at the 10-14 tons/day level.

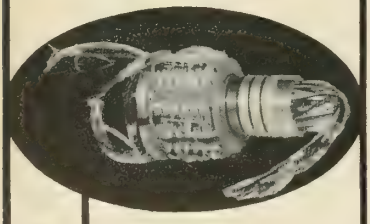
NEW SOLID PROPELLANT gas generating composition: 55-75% ammonium nitrate, 25-45% calcium formate, and ½% calcium stearate. Imperial Chemical Industries developed this pressed charge. The firm has also studied the combustion of methane with oxygen. A CH_4:0_2 ratio of 2:1 gives the most reactive condition, 1:1 is easiest to detonate, while 1:2 was the most flammable . . . Other new solid propellants were patented by Aerojet. One smokeless composite uses trinitrocyclohexylamine (85%) with beeswax (15%). Ammonium perchlorate (50%) and TNT (25%) are used in other propellants using thermoplastic fuel-binders (viz., asphalt-oil) (25%).

CHALK UP ANOTHER COMMERCIAL APPLICATION for solid propellants. NRL has developed a fire extinguisher for use at polar temperatures (to —75°F.). A standard 2½ gal. extinguisher has a head fitted with a nitroguanidine-guanidine nitrate cartridge. The propelling charge gives a 10% increase in extinguisher capacity . . . More lithium compounds for solids are shaping up. American Potash & Chemical is now producing two lithium oxidants—the nitrate and the perchlorate. The latter promises to give the most oxygen per pound of any stable, inorganic compound.



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Astrionics



By Henry P. Steier

Air Force countermeasures equipment requirements for fiscal 1957 was $113.3-million. In 1958 it was considerably more. Total $207.3-million. There's lots of room and an especially critical need for advances in this field. Electronics countermeasures techniques used by U.S. are a well kept secret. It's no secret that traveling wave tubes and other wide-band generators are at the heart of the equipment. In the light of Russian radar advances we're falling behind in finding ways to foil their radar. More power and bandwidth are needed.

Superconductivity may give us new jamming capability. Federal Telecommunication Laboratories reports it is applying superconductivity to an Air Force countermeasures problem. Superconductivity causes a metal's electrical resistance to drop to near zero and involves use of very low temperatures such as the 452.2 degrees F used by FTL. This is near absolute zero temperature and sounds like an excellent way to boost radio frequency efficiency in a traveling wave tube, and thus get great gains in power.

Infra-red countermeasures are likely to crop-up soon. *Sidewinder* missile is said to zip right up the tail pipe of a jet plane because its IR sensing cell looks for the highest intensity IR source. Similar, but "hotter" IR-spots might be created by countermeasures flares using a variation of the old thermite incendiary bombs to create the right kind of infra-red source.

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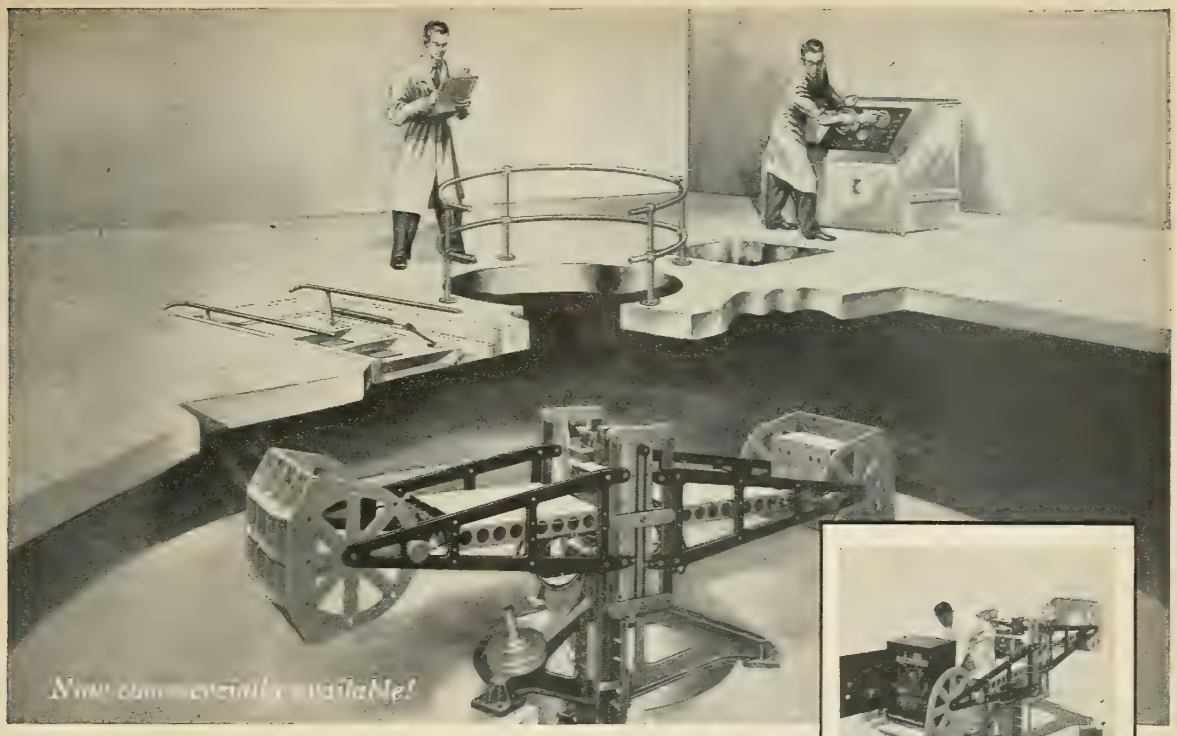
Transducers for missiles are big business. Retirement fund investors apparently think its a stable business. General Electric, U.S. Steel, Bethlehem Steel and Yale University were reported to have invested heavily in Gulton Industries, Inc. recently. Gulton's products are used by every engine, aircraft and missile maker. Important products are accelerometers, pressure gauges, pressure switches, thermistors, ultrasonic equipment, etc. A key material in these is barium titanate which has piezo-electric properties and high temperature capability. They make instruments that work to 800° C. Gulton just sold Convair $1.6-million worth of accelerometer systems for *Atlas* missile project. Devices that fit in palm of the hand cost $900 and have wide sensitivity from ½ to 1000g in one unit. Barium titanate is becoming a critical defense item. Supplied solely by one outfit, Titanium Alloy Metals, Buffalo, N. Y., the material's purity control is a key factor in its application. Even so, Gulton has a six acre lot full of barium titanate rejects. Devices using the material cost $5000-$10,000 per pound according to estimate of Endevco Corp., a competitor in the piezo-electric instrument field.

•

Watch it boys! Original plans to use a two-tone audio signal on a rf carrier to turn satellite's electronics on and off have changed. One tone will be used. Previously reported in this column was big concern of satellite scientists as to whether high-school kids and other amateur hams might build equipment to detect satellites passing and find the key tone to turn it on. John T. Mengel, the satellite's electronics designer says the one tone system will be used because of weight saved. If you don't think weight is a problem, here's the answer. Removal of one tone saves 3 ounces! The press knows the approximate frequency to be used. Let's hope it doesn't broadcast it.

•

It had to happen! A new company known as Kentron Hawaii Limited, Honolulu, advertises: "Why Honolulu? Honolulu is a modern American community in the center of the Pacific and is *2400 miles closer to military electronic problems* in the Pacific area than the west coast of the United States." Kentron manufactures tubes and supplies engineering design services.



New Genisco Centrifuge subjects two 300 lb. assemblies to 100 G's

Genisco's Model E185 G-Accelerator, capable of subjecting complete electronic and mechanical systems to G-loadings that simulate actual flight operation, incorporates numerous unique features that simplify operation, reduce servicing, and allow precision testing to meet the most stringent military specifications.

The absence of belts, pulleys, and gears permits smooth and vibration-free rotation of the 12-foot rotor so that delicate inertial guidance systems can be tested. The machine is rugged enough, however, to accommodate proof-load testing.

Operation is unusually simple. Operator responsibility has been minimized, with many operational functions being accomplished automatically. Numerous built-in safety features afford maximum protection to both personnel and the machine.

These design features, plus wide flexibility in the use of the machine, reduce maintenance requirements, and together with low initial cost make the Model E the best large centrifuge currently on the market. Complete specifications will be sent on request.

SMOOTH, CONSTANT ROTATION—Hydraulic drive system permits a clean, compact design. Problems of backlash, gear noise, and frequent lubrication are eliminated. Wow and drift during a one-minute period are less than 0.5% of the operating rate at any speed.

SIMPLE SPEED CONTROL—A single handwheel, located on a remote-control console, determines boom speed. Speed adjustments are made quickly without reading complicated scales or dials.

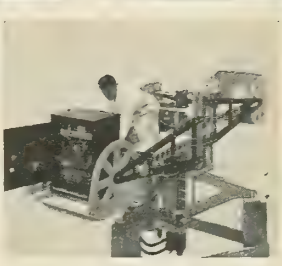
AUTOMATIC DYNAMIC BALANCING—The boom seeks a dynamically balanced condition automatically. Manual computation to determine centers-of-gravity is eliminated.

BOOM SPEED EASILY MEASURED—Coarse speed indication is accomplished by a specially-calibrated tachometer, accurate to within 1% of actual speed. Precision measurements are provided by a pulser/electronic counter, on a 4-decade digital display.

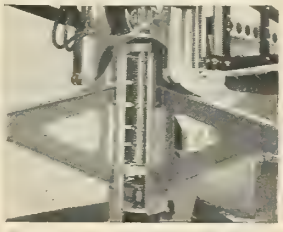
REDUCED HORSEPOWER REQUIREMENTS—By utilizing aircraft design techniques and enclosing the structure in an aerodynamically clean compartment, horsepower requirements are reduced to 15 h.p. for a 100-G machine.

BUILT-IN SAFETY FEATURES—Eight safety interlocks, including three which are key-operated, prevent the machine from being started inadvertently. Removal of any key renders the machine inoperable, permitting the operator to make adjustments to the test object in absolute safety.

CLOSED-CIRCUIT TELEVISION SYSTEM—A closed-circuit industrial television system, incorporating a camera, control unit and remote video monitor, can be provided as auxiliary equipment for the optical surveillance of test objects under acceleration.



MOUNTING PLATFORMS LOCK IN FIVE POSITIONS—The mounting platforms can be locked in the horizontal, 45°, 90°, 135°, and 180° positions, permitting test objects to be subjected to G-loadings through several axes without demounting.



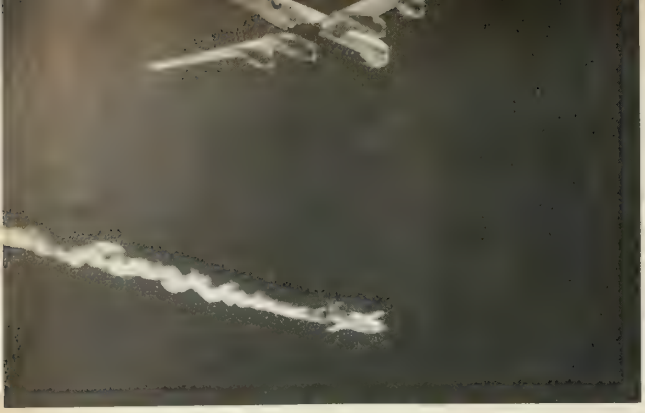
SLIP RING SYSTEM—A total of 48 slip rings are provided as standard equipment in a configuration of 24 unshielded leads rated at 14 amperes maximum, and 24 shielded leads rated at 1 ampere. Brush holders have been removed in the above photograph.



REMOTELY OPERATED—A control console permits complete operation of the rotor assembly from a remote position. All operating controls and switches are located on the console panel.

Reliability First **Genisco** INCORPORATED *2233 Federal Avenue • Los Angeles 64, California*

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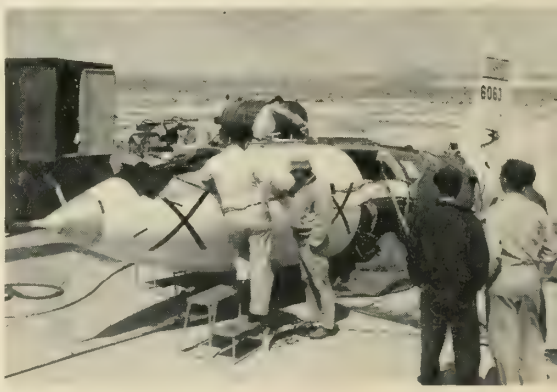
The Bell X-1E was carried aloft by a B-29 over Edwards AFB a few weeks ago for its maiden flight. These exclusive in-flight shots of the X-1E shortly after having been released from the B-29 (and chased by a tracking aircraft) were taken by Loyd Mallan, aviation and science writer. The copyrighted (1957) pictures will appear in Mallan's forthcoming book Rocket Test Pilot.

m/r exclusive:

X-1E Goes Aloft



X-1E is prepared for hook-up to its B-29 mother plane. Pilot's breathing oxygen system is checked at Edwards AFB. X-1E uses advanced pilot ejection seat equipment and modified fuel feed system.



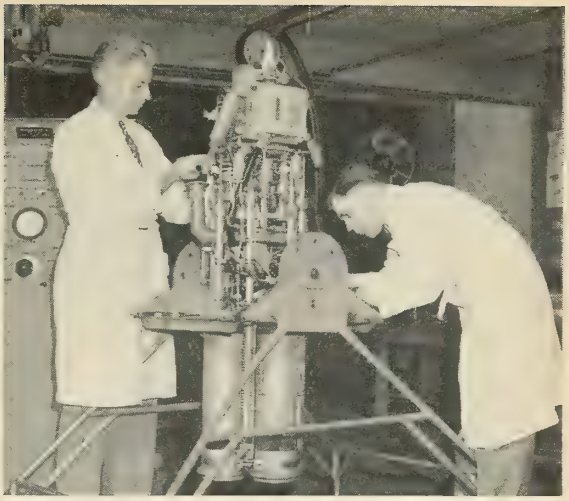
Airplane is readied by NACA, Bell and RMI engineers. First flight lasted for a few minutes and was successful. Landing gear was slightly damaged at landing, delaying the second flight.

The NACA X-1E research aircraft was modified from original X-1 (No. 2) employing 4 per cent thick wing (thickness measures per cent of wing cord) produced by Stanley Aviation Corporation Denver, Colorado. Aircraft is built by Bell Aircraft Corporation



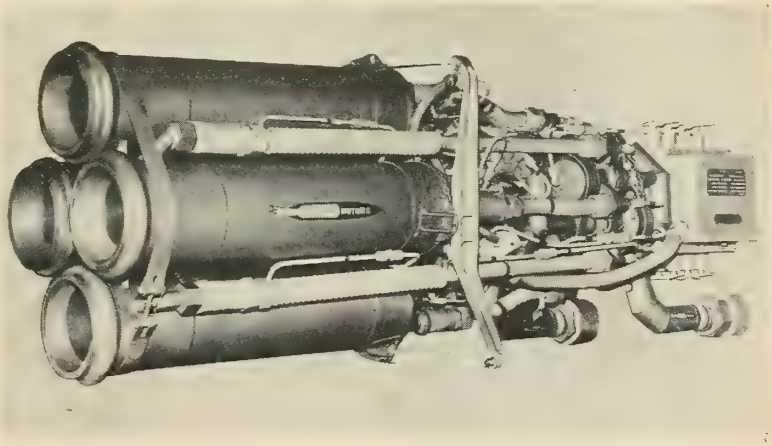


Oxygen is vented to the atmosphere as propellant tanks are being topped prior to takeoff. X-1E has fuel supply for about four minutes. The aircraft obtained a maximum velocity of Mach 2 plus during the first flight. No speed record run was attempted.

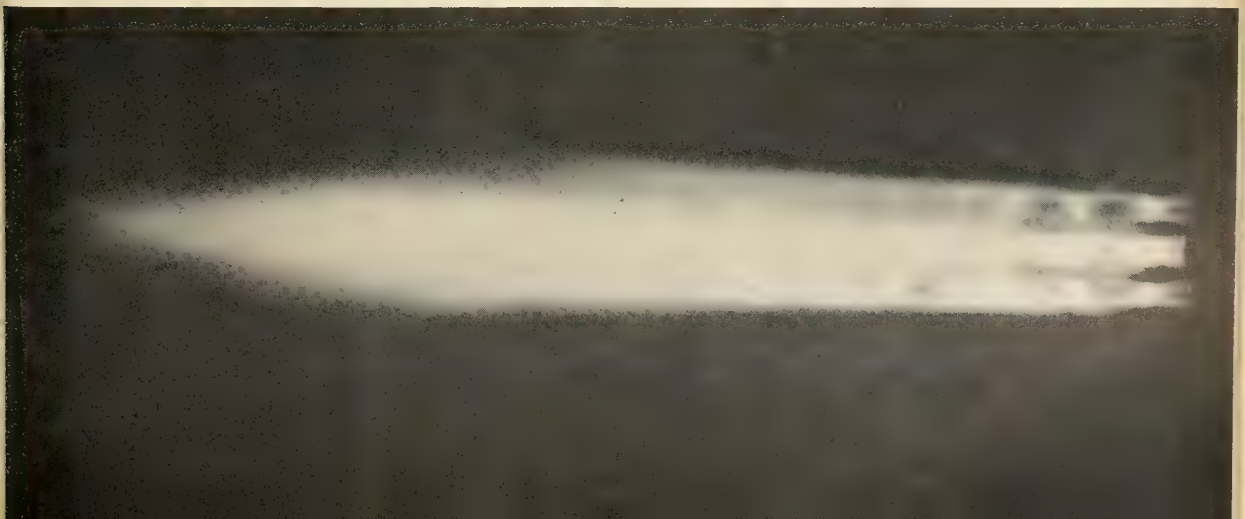


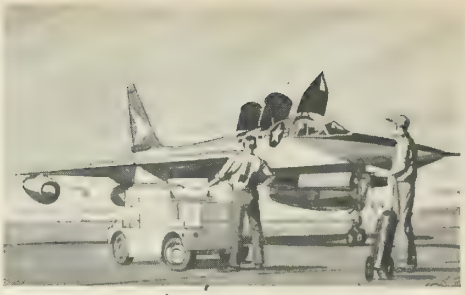
RMI employees, John Wickstead, left, and Holbrook Smith, perform operational check on the 6,000 lb. thrust engine in preparation for test firing. Engine used in the X-1E is designated XLR11-RM-11, basically the same as the one used in the original Bell X-1.

Reaction Motors, Inc., a pioneer company in liquid rocket aircraft engines, has produced a whole series of the 6,000 lb. thrust power plants of the kind employed in the X-1E. The four chambers can be fired simultaneously or in any sequence or combination of one, two, three and four. Each chamber produces 1,500 lb. thrust. Output is controlled by cutting off one or more chambers. Engine uses liquid oxygen and alcohol; pump drive employs peroxide and catalyst.

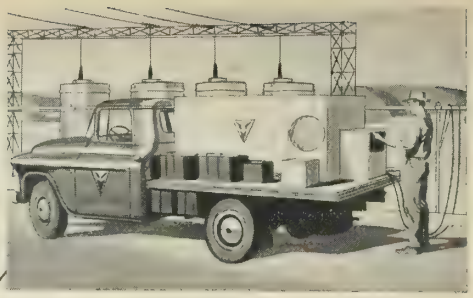


Static test of RMI's FLR11-RM-11 rocket engine at company's New Jersey facility. These engines have been built under both Navy and Air Force contracts. RMI now is working on similar power plants of much higher thrust for tomorrow's experimental rocket aircraft.





Ground support for jet aircraft.

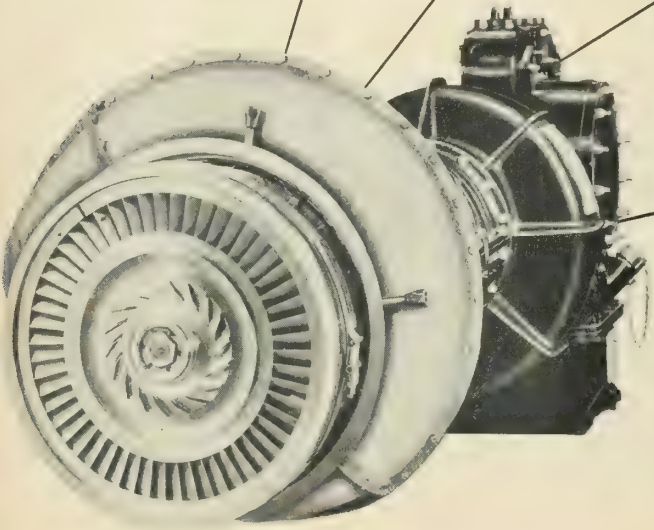


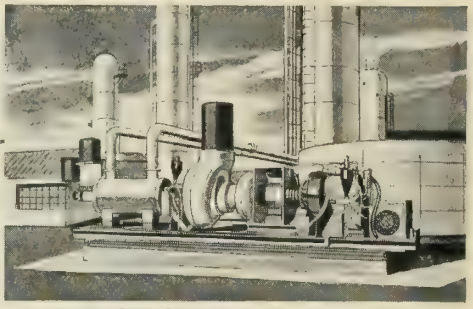
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at the start of the IGY . . .

Project *Vanguard*

Past, Present and Prospects

VANGUARD MAY make it after all if it can clear the red tape. Office of Naval Research Head Rear Admiral Rawson Bennett promises that the first *Vanguard* vehicle will be ready to try to launch a satellite "in the spring of 1958." Meanwhile the first blush of pride and prestige that flushed the egos of the major subcontractors pales into anger as Project *Vanguard* wallows in fantastic bureaucratic mire.

During the International Geophysical Year the U.S. will launch 193 research rockets to altitudes up to 200 miles from Fort Churchill Canada; White Sands N. M.; Guam; and from ship board from pole to pole. These will include 42 *Aerobees* 14 *Nike-Deacons* 52 *Nike-Cajuns* and 85 *Rockoons*. But from a publicity point of view at least the six scheduled U.S. attempts to place four artificial satellites in orbit is the biggest deal of all.

It's also big from a money point of view. Traceable costs of the $39-million project already exceed $50 million. Real total may top $100-million.

Eulogized and advertised ad nauseum as mankind's greatest adventure there is still no assurance that any of the *Vanguard* satellite-launching attempts will be successful during the 18 months of the IGY. It's the nature of the still-young state of the rocket art.

Even if *Vanguard* is ready by spring, it still may not be first. Reports point to a Russian try within 10 weeks. And to the south the missile team everybody tries to ignore may beat even that date.

For some still unexplained reason, no *formal* approach has ever been made to the highly successful Wernher von Braun rocket team at Redstone Arsenal, Huntsville, Ala—despite the fact that *Redstone-Recruit* satellite launching hardware has been in being at the arsenal for nearly a year now.

Off the record, however, Dr. John P. Hagen, Project *Vanguard* Chief, and his Naval Research Laboratory associates have more than once gazed with interest if not envy, on Dr. von Braun's stepping stones to space flight. And, within the last few months, the Army has developed its own satellite transmitter. There seems to be a possibility, in fact, that the Army may have been placed on unofficial stand-by alert—just in case.

The recent three-day special meeting of the U.S. National Committee for the IGY at the National Academy of Science, Washington, D. C., provided the most details of the official satellite program released to date. Particularly revealing were papers by Dr. Hagen and by Dr. R. W. Porter, Chairman, Technical Panel for the Earth Satellite.

Project *Vanguard's* target is to place an instrumented sphere with a diameter of 20 inches and a gross weight of 21½ pounds in an orbit at a nominal altitude of 300 miles—perigee no less than 200 statute miles and apogee no more than 1400 miles—with an inclination of the orbit to the equator of 40° ± 5°; to be launched from Patrick Air Force Base, Fla. Required orbital velocity is 25,000 feet per second. Latest estimate puts its period at 100 minutes.

The original idea, according to Dr. Hagen, was to use as many "off-the-shelf" components as possible; "to use a configuration for which the preliminary design had already been done and to employ a rocket vehicle contractor who had intimate and recent experience in the design and manufacture of research rocket vehicles and who had experienced engineering personnel."

Prime vehicle contract went to The Martin Company, which had previously made the *Vikings*. General Electric received a subcontract to modify the less-than-20,000 pounds thrust *Hermes* engine into an over 27,000 pounds thrust *Vanguard* first stage. Aerojet-General would adapt the Aerobee main engine into a second stage.

Selection of a three-stage vehicle with a minimum gross weight of 20,000 pounds required, Dr. Hagen said, "a *minimum* thrust level for the first stage (for safe takeoff) of 27,000 pounds . . . (This) dictated to a large degree the characteristics of the remaining propulsion systems."

This prediction of stages two and three by stage one may explain why GE's hopped-up *Hermes* engine, was first rejected as unsatisfactory and then hastily and unexplicably reinstated. Had it been dropped, the whole project might have had to be re-engineered. Meanwhile, it isn't certain the first stage engine's problems have yet been solved. G.E.'s Dr. Porter, referring to the fact that the last of the Nunn-Baker satellite cameras will not all be in place before March, 1958, said: "This may therefore be the limiting part of the entire satellite program, *with the possible exception of the booster vehicles.*" He could also have been talking about his own company's first stage engine.

An example of how *Vanguard's* too many generals have really hauled out the red-tape lies in the difficulty of finding out just what *is* going on. Obtaining specific information from the various *Vanguard* chiefs and contractors is now almost impossible.

The "security" system for controlling the release of information about this project of "no military significance" seems more calculated to give everyone a chance to check for possible embarrassment. The system would do justice to political censorship in the Kremlin!

No information may be released under the name of any Martin Company subcontractor unless it has first been checked either for "technical accuracy, military security or both" by: The Martin Company; NRL's Technical Information Office; NLR's Security Office; Admiral Bennett, ONR; Office of the Chief of Naval Information; Department of Defense Office of Public Information (including representatives of Army, Navy, Air Force and DOD); Central Intelligence Agency; State Department; National Science Foundation; and National Academy of Science (U.S. Committee for the IGY).

Since, in the final analysis, NRL alone would suffice to assure technical accuracy and protect military security, it must be assumed that *Vanguard* is politically a very sensitive vehicle. Says one important subcontractor: "It is just disgraceful!"

However, m/r has been able to determine that: Aerojet-General's second stage engine is ready to go—no troubles; Grand Central Rocket's third stage flew on the nose of *Viking-14* and "performed like a doll"—no troubles; Raymond Engineering Laboratory's spring-loaded satellite ejector mechanism "is perfect" according to NRL engineers; Atlantic Research has all but finished work on the spin and retro rockets for separating the second stage from the third; Minneapolis-

Honeywell's gyro reference system also appears to be trouble-free and on schedule; Brooks & Perkins' delivery of satellite spheres is ahead of schedule; Allegany Ballistics Laboratory seems to have overcome its early burning problems; Loewy-Hydropress has already delivered the static test and launching platform to Patrick; NRL has instrumentation and circuitry for the satellites well in hand.

Bendix Radio Division is on schedule in the manufacture of Minitrack receiving stations; the 80 U.S. Moonwatch teams have been organized; the Nunn-Baker satellite tracking camera is reported to be experiencing mechanical difficulties, but Perkin-Elmer's optics will be delivered in time for the last of the 12 cameras to be in place by next spring; International Business Machines' 704 satellite data computer is in place and ready to go whenever a satellite is launched; and Army Signal Corps is busy arranging for the instantaneous transmission of satellite data from South American tracking stations.

This quick look at Project *Vanguard's* status would seem to leave the burden of proof of success or failure up to the prime systems contractor, The Martin Company, and the first stage engine-maker, GE. However, a lot of components haven't yet been flown, and until they experience an actual launch and flight, their true readiness will not really be known.

In this last connection, the next *Vanguard* test vehicle shot, TV-2 (TV-0 and TV-1 were *Vikings*), will be a GE first stage with dummy second and third stages loaded with measuring and transmitting gear. If it works, O.K. If not, somebody's got to hop, and fast.

TV-3 will be a GE first plus Aerojet second plus dummy third stage. TV-4 is slated to be the same as TV-3 but with an ABL third stage. TV-5 and TV-6 should be full system test firings —a total of seven test flights before the first shot in earnest.

Statistically, the *Vanguard* launching vehicle is 72 feet long; has a first stage diameter of 45 inches and a second stage diameter of 32 inches. It is finless, employs integral tanks and has a loaded gross takeoff weight of 22,600 pounds.

Its first stage is a liquid oxygen and kerosene motor fed by turbine-driven pumps. Orientation and flight path are maintained through control of the gimballed motor. "The electro-hydraulic controls that position the motor have the necessary response to stabilize the composite finless airframe in pitch and yaw."

Roll control comes from changing the direction of the turbine exhaust. The inertial reference system for guidance is carried in the second stage. In Dr. Hagen's words, "In essence, the first stage is a guided, liquid propellant booster which provides about 65 per cent of the energy to raise the remaining stage to orbital altitude and about 15 per cent of the required orbital (horizontal) velocity."

The second stage uses white fuming nitric acid and unsymmetrical dimethyl-hydrazine fed directly from high pressure integral tanks. In both first and second stages the pressurizing gas is helium. Motor is gimballed, as in the first stage. "An array of gas jets provides roll control during second stage powered flight and complete control of vehicle orientation during coasting flight."

The reference system and flight programmer, both located in the second stage, are responsible for all major in-flight operations, such as change of pitch rate with altitude. The third stage spinning mechanism is also in the second stage.

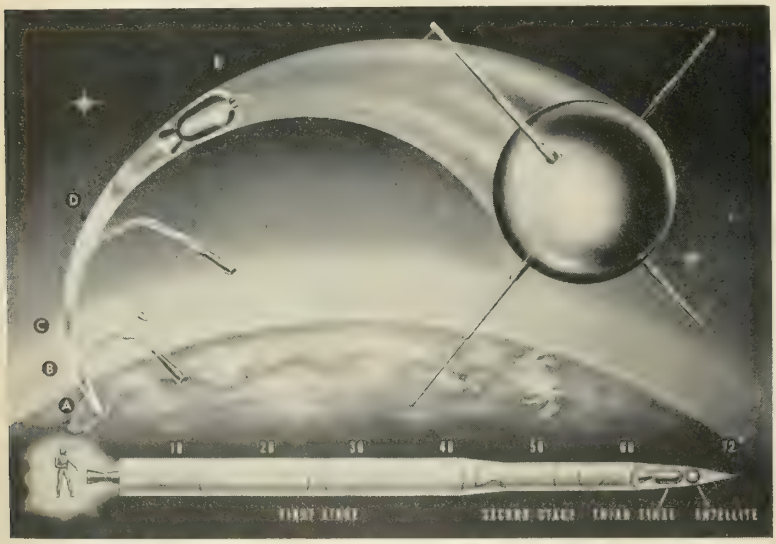
This stage which, fully loaded and including the third stage, weighs about 4800 pounds, contains the brain of the launching vehicle, and supplies the remaining energy required to reach orbital altitude and about 32 per cent of the orbital velocity.

The third stage weighs about 500 pounds fully loaded and is an unguided solid propellant rocket, spin stabilized with its longitudinal axis roughly parallel to the earth's surface. It is fired at orbital altitude and provides 50 per cent of the required orbital velocity, the remaining three per cent coming from the earth's rotation. rotation.

The sequence of events in a "typical" firing will be as follows: vertical flight until "satisfactory" clearance of ground installations; then maintain an approximate zero-normal-force trajectory until aerodynamic forces are no longer critical; first stage separation and second stage start up; jettison nose cone, revealing third stage and satellite, in latter part of second stage powered flight; pitchover after second stage cut-off so that third stage will be fired roughly parallel to the local horizontal; second stage separation and third stage firing; third stage fires until orbital velocity is attained; saltellite ejected from third stage with a differential velocity of three feet per second.

The six planned business shots will hope to get four satellites successfully into orbit. These four will perform basic experiments as follows: NRL's ultra-violet, temperature and meteoric measurements; University of Iowa cosmic ray and AF meteoric experiment; NRL magnetometer and NACA expandable plastic foil sphere experiment; and for the fourth one, a choice to be made "shortly after November first" between University of Wisconsin energy balance and Signal Corps cloud distribution experiments.

Design of equipment for all five of these projects appears to be progressing on schedule and without major hitches.



A bird is an industry: At (A) Loewy-Hydropress supplies launching platform; GE, the first stage engine; at (B) first stage falls off; second stage engine is by Aerojet-General and contains gyro reference system by Minneapolis-Honeywell, spin and retro rockets for separating and spinning third stage by Atlantic Research; at (C) during second stage powered flight, nose cone pops off; at (D) second stage falls free and third stage either by Allegany Ballistics Laboratory or Grand Central Rocket propells satellite to orbital velocity; (E) Raymond Engineering Laboratory's ejection device kicks sphere loose with three foot-per-second differential velocity over dead third stage assembly, which becomes a kind of satellite itself.

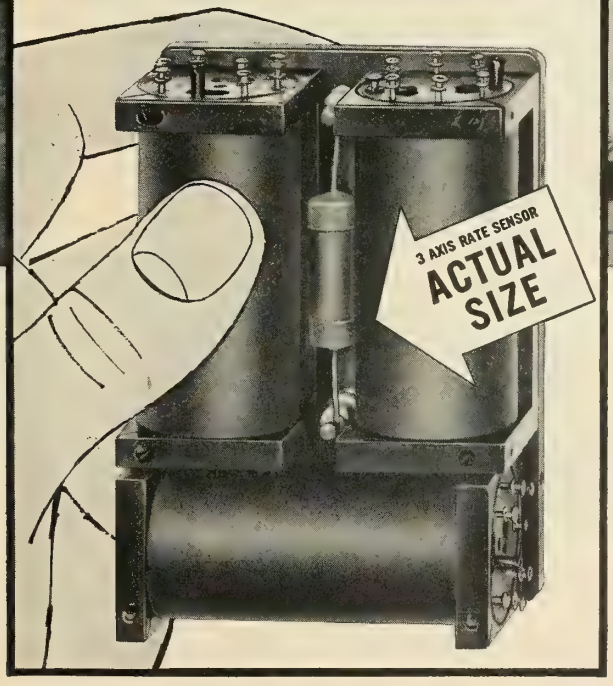
In Control–with U. S. TIME GYROS



Poised on their launchers, the Navy's Terrier guided missiles... Official U. S. Navy photograph.

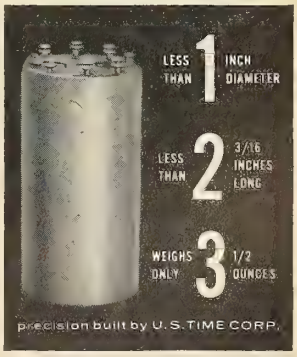
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ELECTRONICS EVOLUTION

The 1957-60 missile era may some day be referred to as the period in which electronics first came into its own as a 50 per cent partner dollar-wise with the missile frame and propulsion business.

The specific spending picture for missile electronics is clouded by security and hidden factors in any accounting breakdown available. Despite this, a conservative estimate for 1957 spending shows electronics to be well along toward 25 per cent of the total $2.3 billion missile business.

Of the approximately $600 million for electronics about half is for missile-carried gear and the other half for ground gear. For the Air Force alone the dollar volume picture for aviation and missile electronics will expand over 100 per cent in the next few years, according to a recent estimate of USAF Maj. Gen. David Baker, Air Materiel Command. The Navy and Army needs must be added to this.

As things stand by 1960 a predicted $1-billion missile electronics business seems as sure as the importance of making missiles go where we want them once they are fired.

At the present time missile guidance and control in operational, developmental and research missiles ranges from the "puppet-like" guidance of the Army's *Dart* through a wire cable attached to the missile to the ultra-sophisticated (for 1957) attempts to design a 5000-mile ICBM that will reach its target point without any ground-communication guidance over at least half its trajectory.

Between these two extremes are various systems using either electromechanical inertial techniques coupled with some electronics or pure electronics for guidance.

These might be defined as:

Closed-loop guidance:

1) *Nike* is typical of this method, as are the new *Talos* and *Terrier*. *Nike's* guidance is based upon information acquired by radar, calculated by a ground based computer and then sent to the missile as commands. Even the firing of *Nike's* three warheads is done by command.

Talos and *Terrier* use a refinement of this technique. They seek out the rider beam of a two-beam radar and then switch over to a proximity system during the terminal part of their flight. The beam system uses track and capture beams sent by one radar antenna system. The track beam follows the target. After launching, the missile seeks the capture beam that leads it to the target's vicinity.

2) *Bomarc* utilizes computer-derived information from the Semi-Automatic Ground Environment system being implemented for continental defense. *Bomarc's* position is relayed by data link equipment on board to a SAGE center. Directions for interception of its assigned target come back to it through the data link for guidance to the terminal area. Near its target it uses radar equipment similar to interceptor fire control to "lock-on" to its target for a kill.

Self-contained:

Early user of this technique was *Matador*. An inertial system on board is distance-direction programmed to carry the missile to its target and to program the terminal dive. Recently reported was guidance of *Matador* by utilization of low frequency hyperbolic navigation signals such as produced by Decca, Cytac and Radio-Web.

Snark and *Navaho* use a hybrid system combining inertial navigation with celestial position fixing. The enroute flight is preprogrammed through the inertial system and periodically corrected by automatic star-sighting equipment on board.

Target seeking:

Early user of this technique was the *Corporal*. The same technique seems to be the mainstay of current hopes for ballistic missile "guidance." The short range *Corporal* is guided during the first part of its flight by radio commands. These are derived from Doppler radar and optical data on the missile's initial trajectory. Adjustments to correct the trajectory are sent to establish the required ballistic path for a particular target. The same general technique is applied to *Redstone* and is believed planned for missiles such as *Atlas, Titan* and *Jupiter*.

Guidance of an ICBM has been described as "shooting through a hole in the sky 800 miles up." That "hole" will be the ideal point in outer space for the ICBM to go through if its calculated ballistic trajectory is to carry it to the target. But how is "hole in the sky" found and how can the missile men be sure of the trajectory?

There have been numerous reports that radiometric corrections will be applied to the ICBM flight during the find-the-hole flight stage. Other reports have said that radiometric correction was abandoned in favor of inertial programming.

The handicap of intense ionization around an ICBM and the inability of radio energy to penetrate the ion sheath would probably limit the range over which control could be exercised. Once up to full speed, radio control could be impossible. Inertial control would not have this handicap, but would probably be less accurate than the best radiometric techniques.

Although the manufacturers of gyroscopes and accelerometers have made phenomenal progress in raising the precision of guidance it seems apparent that in the long run electronics will win out. It's hard to compete with the speed of light and precision control advantage in radiometric methods.

A big item in planning for ICBM operational centers are the computers that will be needed. They will undoubtedly do the job of taking the myriad and varying conditions under which an ICBM will perform and integrating them to determine where that "hole in the sky" should be at any given time and place the ICBM is launched.

Only recently Cornell Aeronautical Laboratory dedicated an IBM 704 scientific computer for ICBM work. Purpose, it was stated, is to provide a complete table of properties of air at high temperatures. Over half-million thermodynamic values covering the properties of air for some 8000 different cases of temperature and density will be computed.

Microminiaturization of electronics is just starting. With improved sensors and high power computers in a tiny package missiles may some day need only the latitude and longitude of the ground target to find their way at any speed and from any altitude.

This same electronic "brain" together with ultra-advanced sensors may also make possible counter weapons capable of seeking out and destroying missiles attacking from outer space.

TELEMETERING BY ASCOP

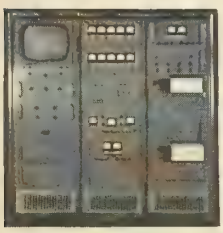
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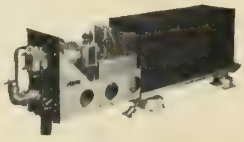


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on the following pages
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** Some of the specifications and performance figures given for the missiles and rockets in this encyclopedia have been calculated and have not necessarily been officially confirmed.*







U.S. Army's NIKE AJAX

Nike-Ajax, named *Nike* after the Greek goddess of victory, is the Army's first supersonic antiaircraft guided missile designed to intercept and destroy the enemy target regardless of evasive action. *Nike* guided missile units are now deployed around vital industrial, highly populated and strategic areas of the U.S.

Nike-Ajax is a missile about 20 feet long and about one foot in diameter, with two sets of fins for guidance and steering. It is boosted to supersonic velocity by a solid-propellant booster and maintained by a liquid sustainer motor. The missile and booster weigh more than one ton.

Speed, range, altitude and lethality of *Nike-Ajax* can meet an attack from any direction and its kill potential has far exceeded expectations. There are 12 launchers in each *Nike* battery, each battery being operated by approximately 100 officers and men. Personnel are trained at the Anti-aircraft and Guided Missile School, Fort Bliss, Tex., and the Ordnance Guided Missile School, Huntsville, Ala.

The *Nike-Ajax* system consists essentially of a two-stage missile and elaborate control equipment requiring approximately 1,500,000 separate parts. The missile is about 20 feet long and one foot in diameter with two sets of fins for guidance and steering. Its weight is more than one-half ton.

Inside the *Nike* are an explosive warhead, a guidance unit, and a propulsion system consisting of two propellant tanks, an air tank, and a rocket motor. When the missile takes off, the initial seconds of flight straight up are powered by the solid propellant booster rocket which drops off before the *Nike* turns and heads for the target at supersonic velocity. After the booster falls away the missile's own rocket motor begins to generate power and the second stage of the trajectory begins.

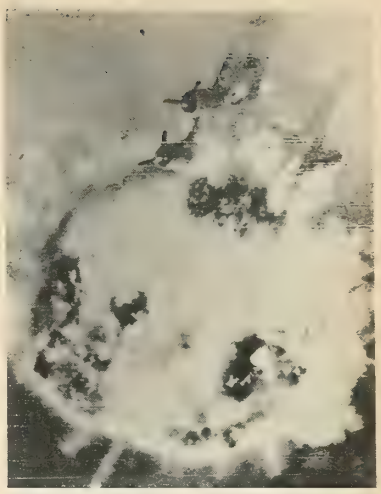
Control equipment consists mainly of three radars, an electronic computer, and automatic plotting boards. This is the combination of intelligence that detects approaching enemy aircraft and directs the *Nike* to the spot in space where they will meet and the warhead will be detonated.



Nike Ajax batteries ring most important cities in the U.S. today. Missile has demonstrated its kill capability against slow drones. Nike still is considered effective.







First of the radars, the acquisition radar, detects a target aircraft at long range and alerts the battery control area. A second radar, called the target tracking radar, picks up the aircraft at a closer range. Then information of the target's position and speed is continually fed to an electronic computer whose job is to keep track of the target and the missile when launched, so that it can determine the commands to be sent for optimum interception.

In the meantime, the third radar which follows the missile, supplies information on the *Nike's* position to the computer. Commands to direct the flight are determined by the computer and transmitted to the missile's guidance components which in turn cause the steering fins to move in the proper direction. Any evasive action by the target is instantly detected by the target-tracking radar and transmitted to the computer. The computer re-evaluates the trajectory of the missile to meet the target's change of direction and appropriate steering signals are transmitted to the *Nike*.

The *Nike* battery control officer sits in his control van located in the same area as the three radars and computer. He is responsible for the execution of the entire operation and he alone makes the final decision to fire. Information is constantly fed into the control console to enable him to make this crucial decision.

When notified by early warning radar networks of unidentified aircraft approaching his defended area he orders "Battle Stations!" and sets the launching into action. Previously prepared missiles and boosters are raised to the ground surface on elevators from the underground launcher installation. Propulsion and guidance components have been previously checked, propellant tanks filled with acid and JP-4, and the warhead installed. *Nikes* are loaded on the four launchers associated with each underground installation and final tests and checks are then completed.

When unidentified aircraft come into the range of the acquisition radar the information is presented on the scopes in the battery control van. The target is still far away and out of sight of everything but the radar's searching beam, but at this point the control officer gives the word to "Engage!" and the command is relayed to the launchers. The missiles now are erected to firing position.

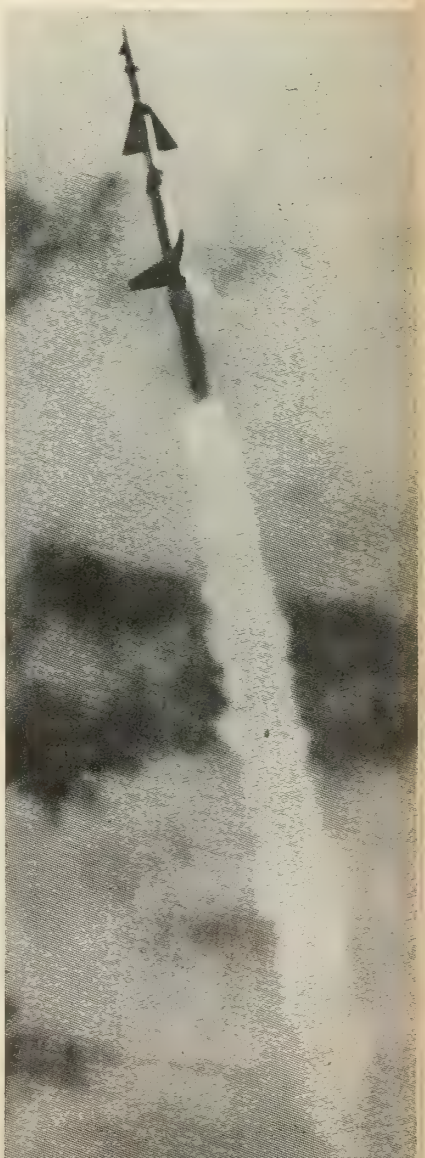
Next the battery control officer must decide when to fire. Hesitation or a mistake might let the bomber slip in close enough to drop his atomic weapon. The battery is placed under its final "red" alert status and the missile tracking radar slews and locks on the first missile to be fired. As the target approaches the maximum range of the *Nike*, the firing button is pushed.

• • •

SPECIFIC DATA:

MANUFACTURER:	Douglas Aircraft Co. Western Electric
MISSION:	surface-to-air
RANGE:	10 to 30 mi.
SPEED:	1,500 mph
WEIGHT.	1,000 lbs.
WAR HEAD WEIGHT:	300 lbs.
LENGTH:	20 ft.
DIAMETER:	1 ft.
SPAN OF NOSE FINS:	2 ft.
SPAN OF TAIL FINS:	5.25 ft.
COST:	$20,000
STATUS:	service

• • •



Nike Ajax being boosted to altitude in test firing. Douglas Aircraft developed the Ajax. Western Electric produces guidance equipment. The system consists of 1.5 million parts.

U.S. Army's HAWK

Despite the frightening array of super-weapons funneling down the research and development pike, warfare sooner or later gets down to the messy foot-sloshing business of ground-fighting. This means low-flying attack aircraft and short-range missiles doing a tactical airpower job must be contended with.

The Army's answer to this requirement is a highly mobile missile called the *Hawk*.

Approximately 17 feet long and 14 inches in diameter, the *Hawk* is deployed on an unusual triple launcher from which three of the weapons can be fired in rapid sequence against low-flying aircraft.

Development of the new air defense system was carried out by Redstone Arsenal scientists under the direction of Dr. Martin Schilling.

Hawk is described by the Army as capable of operating both in the continental U.S. air defense complex at fixed installations as well as with mobile combat troops of the field Army. It may be transported on the highway with a minimum of vehicles or flown by helicopter or aircraft. It will be adopted both by the Army and the Marine Corps.

The new *Hawk* will probably be installed first at sites in the New York City and Washington-Baltimore areas and later at emplacements in other cities where it will very likely replace or supplement the *Nike* chain of air defense weapons. Each battery will require some 40 acres for emplacement.

Prime contractor for the *Hawk* is Raytheon Manufacturing Co.'s Andover, Mass., plant. Northrop Aviation Co. of California is the major subcontractor. *Hawk* uses a solid fuel engine developed by Thiokol Chemical Corp. at its Redstone Arsenal installation.

Hawk uses guidance techniques said to be unusually successful in hunting down and destroying attacking aircraft. Unusual radar instrumentation has been designed and installed in the *Hawk* to gain effectiveness in the so-called "blind zone" of conventional radars. It has also been spoken of as a possible bomber defense missile.

Pilot production of the *Hawk* has already begun at Raytheon, with full production scheduled for the near future.

• • •

SPECIFIC DATA:

MANUFACTURER:	Raytheon Manufacturing Co.; major sub contractor, Northrop Aircraft Co.
MISSION:	surface-to-air
RANGE:	15-plus mi. slant trajectory
VELOCITY:	highly supersonic
LENGTH:	16 ft. 4 in.
DIAMETER:	14 in.
SPAN:	47 in.
GUIDANCE:	radar
POWERPLANT:	(1) SPR Thiokol
ALTITUDE:	sea level into stratosphere
STATUS:	final development

REMARKS: gap between zero altitude and minimum NIKE capability.



Army HAWK missiles on mobile launcher.



Furious blast-off of Army's new AAM.

U.S. Army's NIKE-HERCULES

Integration of *Nike-Hercules,* Army's latest surface-to-air defense missile, into existing *Nike-Ajax* batteries will begin within the year. An advanced version of the *Nike-Ajax,* the *Hercules* has about three times the range of the operational *Ajax*. The final testing phase of the *Hercules* is being conducted at White Sands Proving Ground, N.M.

Hercules is actually a "double" *Ajax*. It is longer, heavier and more than double the diameter of *Nike-Ajax* and capable of extreme maneuverability at altitudes far in excess of those achievable by the *Ajax*. The most outstanding feature of the missile is its three-barreled solid-propellant booster. The increased rate of climb to altitude will permit swifter interception of the most advanced types of aircraft and its vastly increased range will make it the most effective operational air defense missile in the United States.

The atomic warhead of the *Hercules* is designed to insure that detonation occurs only at altitudues sufficiently high to prevent damage to friendly surrounding terrain. It can engage and destroy single or formations of aircraft.

The missile is 27 ft. long, 2 ft. in diameter; booster is 14.5 ft. in length. It is reported to have a slant range of approximately 70 miles.

The design, development and production of the missile system by the Army is the result of extensive coordinated efforts by the Army Ordnance Corps, Western Electric Co., Bell Telephone Labs., and the Douglas Aircraft Co. The *Nike-Hercules* is to be produced initially at the Douglas Aircraft Santa Monica plant and followed with additional production at the Douglas-operated Charlotte Ordnance Missile Plant at Charlotte, N.C.

Fuels and acids used in the missile for propulsion have contributed to corrosion in present *Nike* models. The incorporation of a solid propellant sustainer unit in *Nike-Hercules* will eliminate the corrosion problem. Fueling, handling and storage problems for *Hercules* launching sites will be simplified or eliminated completely.

Meanwhile, the Army has requested funds to support continued development of the *Talos* as a possible supplement to *Nike-Hercules.*

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SPECIFIC DATA:

MANUFACTURER:	Western Electric Co. Douglas Aircraft Co. Bell Telephone Laboratories
MISSION:	surface-to-air
RANGE:	70 mi.
VELOCITY:	2,000-2,300 mph
LENGTH:	27 ft.
DIAMETER:	2 ft.
POWERPLANT:	sustainer (1) SPR Thiokol booster (3) SPR
STATUS:	development & production



NIKE HERCULES in firing position.



New NIKE being tested at White Sands.



U.S. Army's

DART

The Army's end-product concern remains ground-fighting. This means foot-soldiering and everything that goes with it, not the least of which are heavily armored, heavy fire-power vehicles such as the modern tank.

By the end of World War II a reasonably effective series of weapons had been developed to combat these units—the bazooka and both 75 mm and 105 mm recoilless rifles. These were the first rocket power systems to be effectively used against tanks. But they left considerable to be desired.

They had to be aimed, often at a target moving 30 miles an hour. There was no in-flight guidance, and once the recoilless rifle had fired, its position was given away by its back blast. Furthermore, these weapons were within range of an enemy tank's guns.

The Army's highly mobile, versatile *Dart* suffers none of these disadvantages. The wire guided missile can be fired from either fixed or mobile positions, such as jeeps and helicopters. The *Dart's* range exceeds that of any known tank armament. Its velocity in flight is such that possibilities of shooting it down en route are very slim.

But its main beauty is the simplicity of its guidance from the point of view of the firing crew (one man, if necessary). The operator controls the flight of the *Dart* through a special telescope where his only duty is to keep the image of the missile on the image of the target. The guidance system automatically computes the problem and transmits the proper signals to the missile by means of electrical impulses through the trailing wire.

Furthermore, being wire guided, the missile is virtually jam-proof. Contrary to expectations, no problems have been reported from breaking wires. The *Dart* uses a single solid propellant rocket for propulsion.

Wire guidance for airborne missiles probably began first with the Germans near the end of World War II. They made a few firings with an air-to-ground guided missile electrically guided through a trailing wire, but they didn't have much luck. The design was never really put into service.

The French made the first real efforts to develop wire guidance, first with the Nord SS-10 and later with the SS-11. These missiles are in production in France now. Their disadvantages are that their range is less than that of a tank's guns; guidance is by straight visual reference; and the in-flight velocity is 328 ft/sec for the SS-10 and 665/680 ft/sec for the SS-11. Ranges are 1.25 and 1.85 miles respectively. Both the velocities and the ranges of these French missiles are considerably under that of the *Dart*. The French missile's main advantage is even greater portability and greater simplicity than its American product.

In one public firing demonstration the *Dart* achieved a 0.01% accuracy by hitting a cloth bullseye just six inches from dead center at a range of 2100 yards.

This missile is not yet officially operational, but is expected to be "very soon." Aerophysics Development Co. developed the *Dart*. A production contract has been placed with Utica-Bend Corp. (subsidiary of Studebaker-Packard). The rocket engine is by Grand Central; optical guidance system by Wagner Corp.

• • •

SPECIFIC DATA:

MANUFACTURER: Utica-Bend Corp. (subsidiary of Studebaker-Packard)
MISSION: surface-to-surface
LENGTH: 5 ft.
DIAMETER: 8 in.
SPAN: 3 ft. (cruciform wings & fins)
VELOCITY: over 900 ft/sec
POWERPLANT: (1) SPR (Grand Central)
GUIDANCE: wire-electrical-optical
STATUS: production
REMARKS: designed as an anti-tank and anti-emplacement weapon; optical guidance system by Wagner.



Aft view of the DART positioned on field launcher ready for firing.



The highly mobile DART is shown on weapons carrier-launcher.

U.S. Army's

LACROSSE



Lacrosse is an all weather missile capable of destroying enemy strong points in the field to supplement air or artillery attack. Essential components of the *Lacrosse* system are the missile, a launcher mounted on a standard Army truck and a command guidance system.

Lacrosse is propelled in flight by a solid fuel rocket motor manufactured by Thiokol. Field units will be able to answer calls for fire in the same time required for conventional artillery and with a rapidity comparable to that of a 105 mm howitzer. The extremely mobile and accurate *Lacrosse* has undergone a series of successful test firings at White Sands Proving Grounds.

Lacrosse was designed and developed by the Cornell Aeronautical Laboratory of Buffalo, N. Y. Production is by the Martin Co. at its temporary Orlando, Fla. location. The recent production contract supplements an existing research contract of over $8 million.

The Martin Co. has let contracts totaling $6,031,950 with Thompson & Street Co. of Charlotte, S. C. for construction of a new plant at Orlando, Fla., location of its present *Lacrosse* missile production.

The new facility, situated on a 6,777-acre site purchased by Martin last September, is slated for use in R&D and production of newer weapons in the missile, electronics, nucleonics and small weapons fields.

Martin is handling *Lacrosse* manufacturing in interim facilities near Orlando and presumably will shift this activity to the new plant when completed later this year. Plans for the new structure calls for about 488,000 sq. ft. in four buildings. Main building measuring 640 by 500 ft. will provide 290,000 sq. ft. of manufacturing, assembly, shop and storage space.

Four fins positioned 45 degrees from the plane of the wings and at the aft end of the fuselage are movable for flight control and stability. Range of the *Lacrosse* is approximately 20 miles.

With the addition of the *Lacrosse*, supplementing the role of *Little John* and *Honest John*, the field artillery has stacked up a formidable arsenal for close support of the ground troops.

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SPECIFIC DATA:

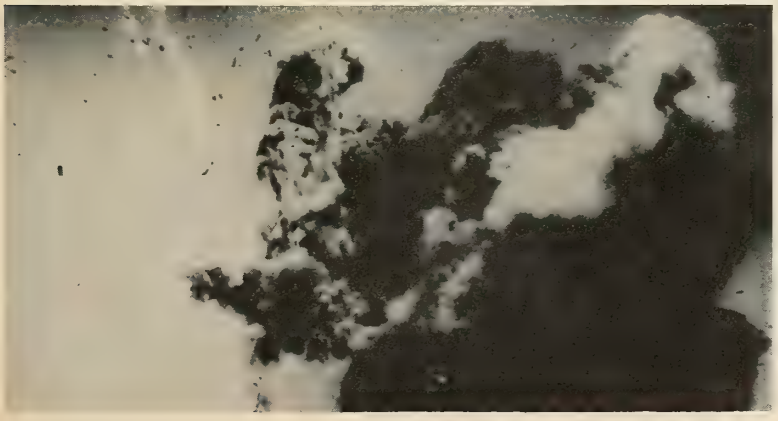
MANUFACTURER:	The Martin Co.
MISSION:	surface-to-surface
RANGE:	15-20 mi.
LENGTH:	20 ft.
DIAMETER:	20.5 in.
SPAN:	wing—108 in. tail fins—87 in.
POWERPLANT:	(1) SPR Thiokol
STATUS:	quantity production

REMARKS:

Federal command guidance system; controlled by forward observer







Lacrosse in action. From the top: Missile leaves launcher, in flight to the target buries in target and explodes with deadly accuracy. Target and impact information is relayed to the launching position by a forward observer.

U.S. Army's

LITTLE JOHN



LITTLE JOHN atomic missile reaches for the sky after firing from White Sands, N. Mex.

For Redstone's 400-man Rocket Development Laboratories, *Little John* has been a manifold triumph. The 12½ inch, 318-millimeter rocket, about 12 feet long and packing the explosive power of heavy artillery, was successfully produced and demonstrated in a crash program that started in February 1956. It was test fired in June 1956, only a matter of months after initiation.

Honest John filled the need for a free-flight rocket artillery weapon with high accuracy, simplicity of design and operation, extremely high mobility, no electronic controls and a range equivalent to medium-to-long-range artillery.

The dimensions of *Little John* are about one-third and its weight one-sixth that of its predecessor. It can be carried in a helicopter. *Little John* thus represents perhaps the growth of a new family of rocket weapons that ease logistical problems and give Army field commanders a wider choice of warheads for use against combat targets.

It was determined that if the Rocket development Laboratories, a part of Redstone's Ordnance Missile Laboratories, directed by Col. Miles B. Chatfield, conducted the *Little John* program as though they themselves were the prime contractor, they would thus acquire invaluable experience in the painstaking coordination essential to development and manufacture of today's complex weapons systems.

Under the direction of OCO (Office, Chief of Ordnance), the task force itself provided the necessary research and development work and guidance in design control, aerodynamics, metal parts and powerplant. The Allegheny Ballistics Laboratory at Cumberland, Md., supplied propellants. Powerplant metal parts were fabricated by consolidated Western Steel of Los Angeles.

Emerson Electric of St. Louis manufactured the air frame. Army Ordnance's Rock Island Arsenal, Ill. provided the launchers. Proof testing was assigned to White Sands Proving Ground N.M. and by Redstone's own staff. Warheads came from the Army's Picatinny Arsenal at Dover, N.J.



LITTLE JOHN is 12 feet long and 12½ inches in diameter. Fins are moveable and equipped for flares.

First firing tests that saw the *Little John* prototypes burying themselves in the sands of White Sands Proving Ground thus represented careful coordination of effort. Since the production of *Little John* is conducted at Redstone, the Army is able to exercise detailed supervision over all phases of manufacture.

Little John is being developed to supplement *Honest John*. This lightweight free rocket can reach out beyond ranges of any existing tube artillery to increase further the all-weather support capabilities of the ground commander.

A great advantage of this rocket is obviously its high degree of mobility. This is the ideal "fire brigade" atomic missile for the airborne infantryman and it was developed to meet this requirement. *Little John* was first fired publicly at the U.S. Ordnance Annual Meeting in Aberdeen last Fall. Its development is well on schedule.

The first class of key personnel of the Army to be given instruction in the handling of the *Little John* began its studies on June 17th. Classroom work includes orientation in rocket parts, systems and warheads of the 12-foot missile. Ten classes are to be trained, with 20 students to a class. They will then become instructors at other Army installations.

Maj. Gen. H. N. Toftoy, Redstone commander, says the new rocket "proves to be very important in the Army's new mobile 'fire brigade' concept in the air age."

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SPECIFIC DATA:

MANUFACTURER:	Douglas Aircraft Co./ Emerson Electric Mfg. Co.
MISSION:	surface-to-surface
LENGTH:	12 ft.
DIAMETER:	318 mm.
SPAN:	33 in.
STATUS:	production

REMARKS: smaller version of HONEST JOHN; for GTG applications; developed at Redstone Arsenal; shorter range than HONEST JOHN; no figures released

U.S. Army's

HONEST JOHN



HONEST JOHN positioned on rails of its self-propelled launcher in preparation for firing.

This missile system is composed of the missile, a self-propelled launcher and an anemometer to measure the speed of the surface winds. The rocket is approximately 27 feet in length and 30 inches in diameter. It consists essentially of a warhead and the solid-propellant rocket motor with large tail surfaces for flight stability. The launcher is a movable, 25-foot rail mounted on the chasis of a regulation Army truck. The wind-determining equipment is pole-mounted to register the velocity of the surface winds that effect the initial flight of the missile.

Honest John's trajectory to the target is determined by the elevation and azimuth of the launcher prior to firing. The effect of the direction and speed of the surface wind at firing is considered in a final setting of the launcher. A slow spin is imparted to it by small spin rockets which give a more stabilizing effect to the trajectory.

After a few seconds of powered flight, the *Honest John* assumes a free-flight or ballistic trajectory to the target. Finally the warhead system detonates the warhead at the target. Here, in reality, is the baby brother to the 1500 mile ballistic missile, *Jupiter,* that the Army is now developing.

The *Honest John* with a 30-mile range and a maximum accuracy scatter factor at that distance of 150 yards, along with its 21-ton launching system is now air transportable in conventional military transports. Soon to be delivered is ultra-light weight launching equipment capable of being dropped by parachute.

The eight *Honest John* missile launchers currently assigned to the new streamlined pentagonal divisions give unprecedented fire power to paratroopers. A major factor in the Army's overwhelming acceptance of *Honest John* is its extreme mobility and simplicity. It can be moved about at will and fired by fewer than half a dozen men if necessary.

The first separate tactical Army unit to be armed with the 21-ton *Honest John* weapon system (developed at Redstone Arsenal, Huntsville, Ala.), is the recently reactivated 101st Airborne Division, Fort Campbell, Ky.

Named after the famous World War II outfit that distinguished itself in Holland and the Battle of the Bulge, the 101st is termed "the forerunner of divisions of the future".

Trimmed down to 11,500 men and discarding tanks and heavy equipment, the paratroopers of the 101st will serve as trouble shooters and can be completely airlifted on a few hours notice to any part of the world in only half the number of planes required for the 17,500 officers and men of present divisions.

The revamped division is composed of five combat groups of five rifle companies, each with supporting rocket artillery instead of the conventional organization of three regiments with three battalions.

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SPECIFIC DATA:

MANUFACTURER:	Douglas Aircraft Co./ Emerson Electric Mfg. Co.
MISSION:	surface-to-surface
RANGE:	20-30 mi.
WEIGHT:	6,000 lb.
LENGTH:	27 ft.
DIAMETER:	2.5 ft.
SPAN:	109 in.
POWERPLANT:	(1) SPR Hercules Powder
GUIDANCE:	free flight—rail launch
STATUS:	production



Powered by a solid propellant rocket HONEST JOHN leaves rails of launcher. A slow spin is imparted to the missile by small spin rockets.



U.S. Army's CORPORAL

The *Corporal* is this country's first ballistic guided missile. The *Corporal* system consists of the rocket itself, several mobile vans and trucks of guidance and firing control equipment. The missile is about 45 feet long with steering fins located on the very ends of the large stabilizing fins. It weighs about 5 tons fully fueled and ready for launching.

The trajectory problem for the *Corporal* is somewhat simpler than that for the *Nike*. Here, the missile system is concerned with a fixed ground target so that the resulting computing equipment is not as complex. Before the missile is fired, basic firing data is computed for the guidance equipment and entered as "dial settings" in the various vans. Then, after the rocket is launched, minor corrections are made to the trajectory to insure an accurate impact.

Launching procedure is as follows: The missile is erected on its launcher by a large transport vehicle called the erector. Prior to this the propulsion and guidance components have been thoroughly checked for proper functioning, the propulsion tanks have been filled with acid and aniline, and the warhead attached.

Guidance equipment vans are placed slightly to the rear and are warmed up and checked for the required electronic indications that will guide the *Corporal* to its target.

The battery commander has established his communications for control of the firing in this guidance area. Here, also, the fire direction center has computed and determined the firing data for the target many miles behind the "enemy" lines. After the missile has been erected and final preparations completed, the commander orders all stations to stand by for the countdown to firing time.

The firing crew takes cover in the firing pit. In order to coordinate the sequence of operations before the missile is fired, the time remaining to fire (countdown) is announced over a common telephone line or "hot loop" connected to each critical station. All operators follow sets of procedures that insure complete coordination between the ground equipment and the missile as its internal components begin to warm up and prepare for the flight to the target. The commander follows the action of the operational sequence on the hot loop, and then gives the order to fire.

• • •

SPECIFIC DATA:

MANUFACTURER: Firestone Industrial Products Co.
MISSION: Surface-to-surface
RANGE: 50 to 150 mi. variously quoted
SPEED: Mach 3
WEIGHT: 6 tons
LENGTH: 40 ft. (45 and 46 ft. are given by a few references)
DIAMETER: 2.5 ft.



LEFT—CORPORAL leaves launcher in a burst of flame from burning acid and aniline. The missile has a range of about 100 miles. ABOVE—Missile is erected on launcher.

U.S. Army's SERGEANT

Sergeant is the latest addition to the Army's tactical missile arsenal. Powered by one of the largest solid propellant rocket motors yet developed *Sergeant* has been mentioned as a possible *Corporal* replacement. *Sergeant*, extremely mobile, safe for handling and storage and a fire mission dream is a tremendous advance over the complex and logistical problem-loaded *Corporal*.

Sergeant was developed by the Caltech Jet Propulsion Laboratory, pioneers in the field of rocket and missile research and development. Sperry Gyroscope, prime contractor for *Sergeant* production, broke ground on July 1st for their new plant at Salt Lake City. The rocket motor will be produced by Thiokol at their Utah Division facilities near Brigham City. Douglas Aircraft Co. has been unofficially reported as contractor for *Sergeant*'s airframe

Sergeant's rocket motor was developed at Thiokol's Redstone Division near Huntsville, Alabama. Testing of the production motors will be handled by the Utah Division on their new horizontal test stand. The static test facilities are capable of handling solid propellant motors up to 12 ft. in diameter and designed to withstand a two million lb. load.

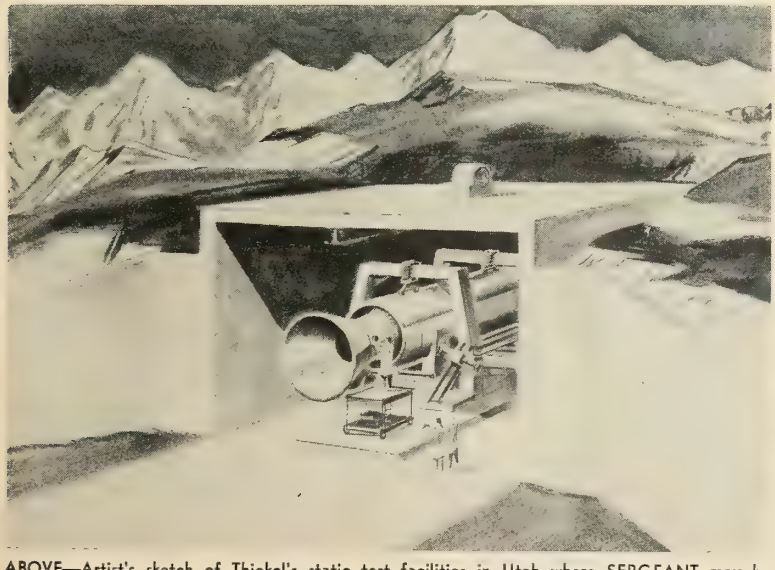
The *Sergeant* has been building up an impressive record of flights as a research rocket. Modified to serve as the first-stage of the X-17 three-stage test vehicle, it has made numerous successful flights from Patrick Air Force Base, Fla. The X-17, designed to test materials for nose cones of ballistic missiles and to solve problems encountered in re-entry of ballistic missiles, is fired vertically into the atmosphere by the *Sergeant* first stage. As it starts to descend the other two stages are fired to accelerate the payload to high velocities.

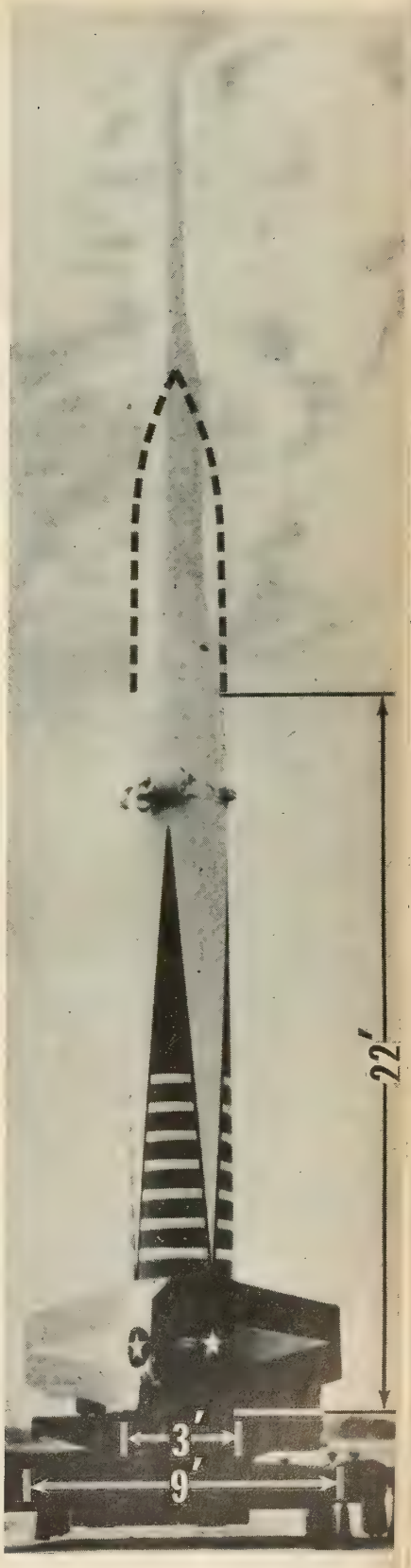
The huge concrete bunker built into the rocky terrain is larger than any other test facilities of Thiokol's divisions at Elkton, Redstone or Longhorn. It is possibly the largest solid propellant test stand in the country.

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SPECIFIC DATA:

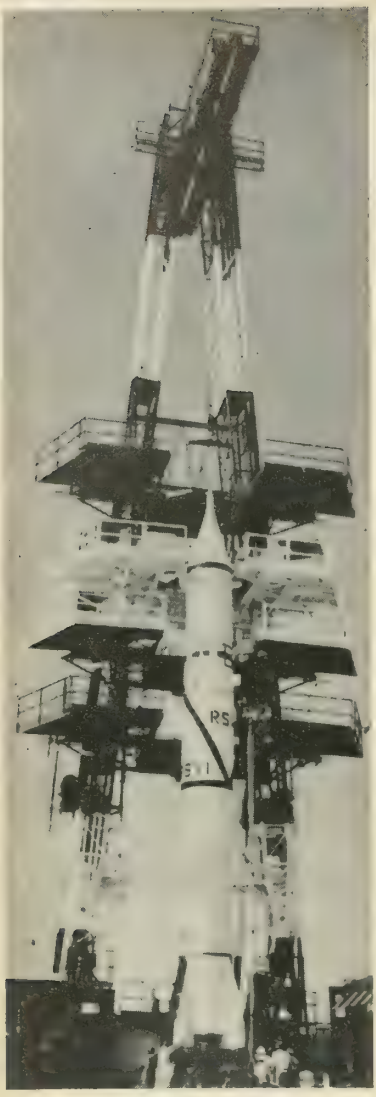
MANUFACTURER	Sperry Gyroscope Co.
MISSION	surface-to-surface
RANGE:	50-75 mi.
WEIGHT:	25,000-35,000 lb. (at launch w/ payload)
LENGTH:	22 ft. (w/o nose cone)
DIAMETER:	3 ft.
SPAN:	9 ft.
POWERPLANT:	(1) SPR 50,000-70,000 lbs. thrust. Thiokol polysulfide cast composite, burning time 30 sec (approx)





ABOVE—Artist's sketch of Thiokol's static test facilities in Utah where SERGEANT may be tested. RIGHT—The possible SERGEANT configuration superimposed on X-17 test vehicle.

U.S. Army's REDSTONE



Army's REDSTONE missile in its servicing station at Patrick Air Force Base, Cape Canaveral, Fla., is being readied for test launching out over the Atlantic Ocean.

Redstone, surface-to-surface ballistic missile, is in quantity production at the Chrysler missile plant at Warren, Mich. The *Redstone* has been described as the prototype for the Jupiter IRBM. The well-tested and successful *Redstone* became the test-bed for guidance and major components of the *Jupiter.*

Range is 200-300 miles although one unit with reduced warhead is reported to have traveled a distance of 350 miles. Powerplant is a North American liquid oxygen-alcohol engine yielding a thrust of 75,000 pounds. This powerplant is considered the most proven of U.S. liquid rockets.

Operational status for this medium-range missile is expected soon. The first *Redstone*-equipped unit, the 217th Field Artillery Missile Battalion, was activated and is being formed at Redstone Arsenal. The first Army Ordnance Corps company organized for the specific purpose of providing supply and maintenance for the *Redstone* long-range rocket has been activated at Redstone Arsenal. It is the 630th Ordnance Company and is assigned to the Army Ballistic Missile Agency. It supports the 217th Field Artillery Missile Battalion which was the first Army unit formed to handle the missile. The 630th's support mission includes responsibility for supply and maintenance of warheads, fuels, the missile and other items of the missile system. The Ordnance Corp's most advance class of officer trainees concluded a one week course of study at the Ordnance Guided Missile School, Redstone Arsenal, in November.

The *Redstone* missile is designed for rough handling and typical field service transportation and environment. Chrysler Corp. has been praised in its effort to make the *Redstone* a most reliable weapon while encumbered with the large amount of complex systems and wiring that make up this missile. Production output and amount of money allocated for the program has not been revealed. It is the largest and most potent of the operational U.S. missiles.

The missile is launched vertically from relatively light portable launching platforms and travels toward its target on a ballistic path. The warhead separates from the missile proper and continues to the target stabilized by four small fins. Warhead compartment will accommodate either conventional or atomic payloads. The *Redstone* recently supplied the major impetus for establishing a new distance record for rocket flight. A modified *Redstone* was used as the first stage of a three-stage assembly known as the *Jupiter C.* The *Redstone* burned out, separated and fell into the sea approximately 100 miles from the launching site. The final stage of the configuration fell into the Atlantic 3000 miles from the pad at Patrick.

The Guided Missile Development Division, under Dr. Wernher von Braun, drew nationwide recognition for its competence in developing the *Redstone* missile. In February 1956 the personnel and facilities of this division were transferred to the new Army Ballistic Missile Agency, specifically established for the expedited prosecution of a program to put the ballistic missile in operational status as rapidly as possible. The *Redstone* is a product of cooperative effort between the Army and private industry, and exemplifies the state of the art in missile development that exists today.

Dr. von Braun, in a recent article



Monitor of aggression . . . giant rocket, Army's REDSTONE, 300-mile missile has just rolled off the assembly line of Chrysler Corporation's Missile Operations. Note the dollies on fixed rail lines, two for warhead and two for engine indicating assembly sequence.



REDSTONE test vehicle for the Intermediate Range Ballistic Missile, JUPITER, illustrates Army step-by-step development philosophy.



Even the big boys fly. Here, REDSTONE missile is shown being eased aboard AF Globemaster for air-freighting to Patrick Air Force Base.

on the philosophy employed in the development of ballistic missiles, stated: "The Army has pursued a minimum-risk program in the development of the *Redstone* and *Jupiter* ballistic missiles which provides optimum development and performance.

"The Army's *Redstone* and *Jupiter* missile programs are being handled by a closely-knit and tightly integrated team with many years of experience in the ballistic missile field. This team consists of experienced scientists and engineers of virtually every field involved in this new art. The need for utmost flexibility during the research and development firing period governs our design philosophy. All the guided missile experience to date, including that on the *Redstone*, indicates that this procedure is an effective and economical one for guided missiles.

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SPECIFIC DATA:

MANUFACTURER:	Chrysler Corp.
MISSION:	surface-to-surface
RANGE:	200-250 mi.
LENGTH.	69 ft.
DIAMETER:	6 ft.
SPAN (FINS):	12 ft.
POWERPLANT:	(1) LPR 75,000 lb trust North American Aviation
PROPELLENTS:	Liquid Oxygen-alcohol
GUIDANCE:	Ford Instrument Inertial Guidance
STATUS:	Production

Mighty REDSTONE thunders towards stratosphere. Missile is development of famous von Braun team at Army's Redstone Arsenal.





Army Chief of Research and Development, Lt. Gen. James H. Gavin, stands beside model of REDSTONE missile, his hand indicating the warhead. This missile is now in production at Chrysler Corp. and is in the process of being weaponized by Redstone Arsenal.



U.S. Army's JUPITER

The *Jupiter* IRBM has scored the first victory in the controversial IRBM evaluation program. After two failures earlier this year, the Army has succeeded in firing a *Jupiter* missile to the limit of its designed range or approximately 1,500 miles. The instrumented vehicle attained an altitude of approximately 250 to 300 miles.

Trouble with the first two *Jupiter* test vehicles apparently stemmed from sloshing fuel. Fix was made by incorporating *Thor* anti-slosh devices in fuel tanks. Anti-slosh devices are reported to be a set of baffles proof-tested in earlier missile flights with similar tank configuration. These were designed to hold fuel slosh to a minimum without interrupting fuel flow. The first two *Jupiter* test vehicles exploded prior to scheduled burnout.

The Army also took steps to eliminate two other potential weak spots in the third *Jupiter*. It removed a gust sensing indicator mounted on a forward probe and installed a heat blanket shield at the base of the missile to prevent eddies of exhaust flame from burning out the control wiring. *Jupiter* has also solved its gas generator exhaust problems by shifting from hydrogen peroxide decomposition to hot gas drive for auxiliary power turbine. The hot gas drive burns missile propellants for operation of the power turbine.

The *Jupiter* carried instrumentation in place of the warhead it would normally carry in operational use. It was controlled by a preprogrammed auto-pilot which held its attitude during flight to the programmed course. Later vehicles will be equipped with a full-fledged guidance system which will include computing as well as sensing elements.

North American Aviation is supplying the same rocket engine for the *Jupiter* that is used by the *Thor*. The similarity of the two missiles will become even more pronounced if the expected airframe switch for the *Jupiter* materializes.

The engine for the *Jupiter* is reported to develop approximately 135,000 lbs. thrust. The missile is approximately 60 ft. in length and 8 ft. in diameter. Separation of the warhead is expected as a performance feature as a result of *Redstone* development.

The Defense Department has removed the Air Force from its funding responsibility for the IRBM program until a decision is made between the *Jupiter* and the *Thor*. Current plans now call for Defense to transfer a portion of its emergency R&D funds to the Army sometime in August to allow the *Jupiter* program to continue. Despite the funding deviation from the Wilson memo, Defense officials emphasized that there is no change in the basic roles and missions assignment.

USAF and Army ballistic missile experts met at the Army's Redstone Arsenal last month for a technical information exchange on the *Jupiter* and *Thor* programs. Nineteen USAF missile experts accompanied Maj. Gen. Bernard A. Schriever, director of ARDC's Ballistic Missile Division, to the Huntsville, Ala., facility. The presentation highlighted the programs achieved by the agency in the development of the *Jupiter*. A joint release stated "The Army is continuing this development under authority of the Secretary of Defense, who has determined that operational employment of the IRBM will be the responsibility of the Air Force." The statement further asserted: "The sole interest of both uniformed services is to provide the best IRBM at the earliest practicable date in the urgent interest of national defense. It is to achieve this objective that we have committed all resources, manpower, facilities and funds for the purpose. Out of this joint effort will emerge the weapons systems determined essential to the security of our country." This statement, coupled with the recent successful firing of the *Jupiter*, lends support to the Army's contention that it can have *Jupiter* operational before *Thor*. It is felt in some quarters that the *Jupiter* has taken a wide lead in the development race. At the same time Air Force officials express doubt that the IRBM will be ready for operational units inside of a year.

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SPECIFIC DATA:

MANUFACTURER: Chrysler Corp.

MISSION: surface-to-surface IRBM

RANGE: 1500 mi.

LENGTH: 50-60 ft. (est)

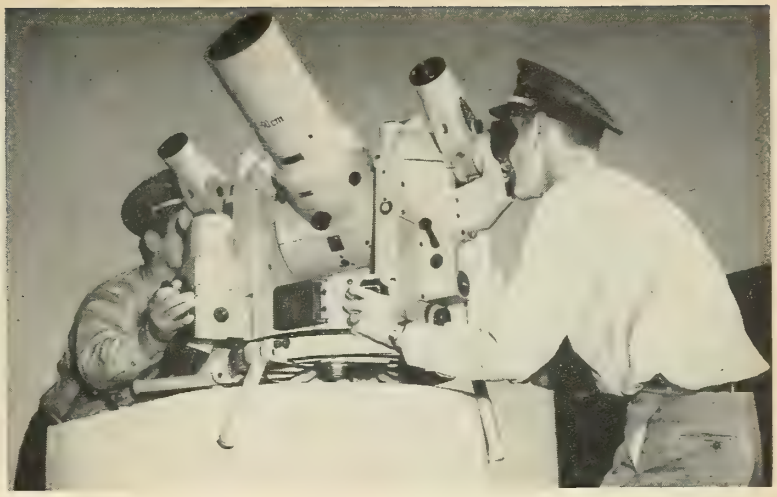
DIAMETER: 8 ft. (est)

GUIDANCE: Ford Instrument Co. Inertial System

POWERPLANT: (1) LPR 135,000 lb. thrust North American Aviation

STATUS: research & development

REMARKS:
thrust control system designed and manufactured by Servo-mechanism



U.S. Navy's
CORVUS

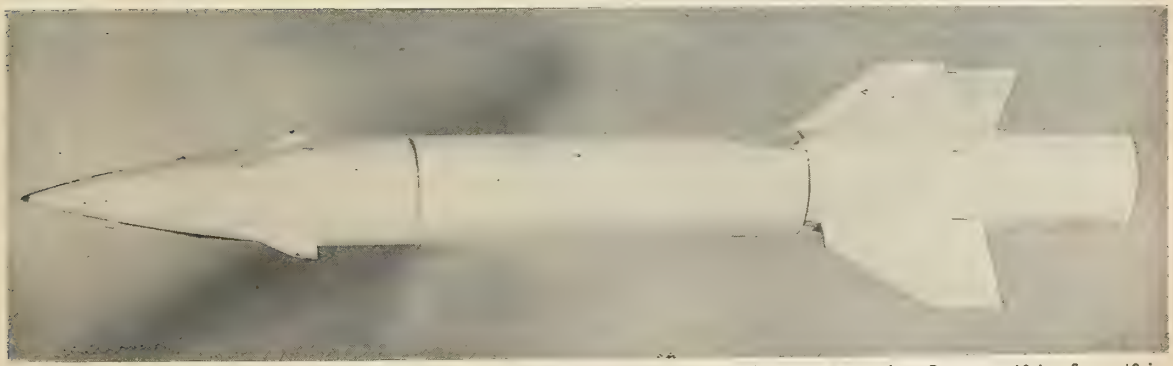
Corvus, which is Latin for crow, is being developed by Temco under a $16 million contract. It is an air-to-surface missile for use on carrier-based aircraft. Navy has issued invitations for new carrier-based craft capable of carrying *Corvus.* The only aerodynamic model of *Corvus* recently completed wind tunnel testing at Massachusetts Institute of Technology. Data submitted by Temco to Navy for clearance is reported to be at the bottom of the list as far as releasing it is concerned.

DIAMONDBACK

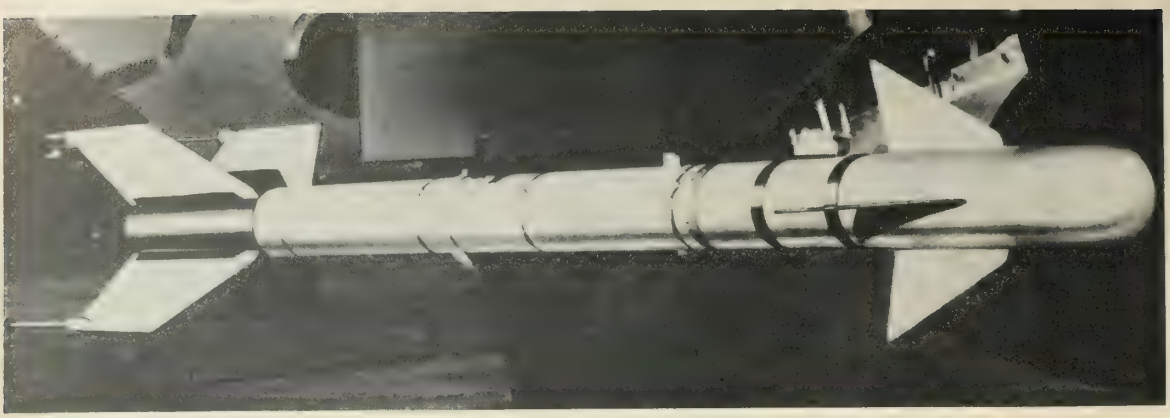
Diamondback is an air-to-air missile believed to be a successor to the infra-red homing *Sidewinder.* It may be one of the missiles in development now known as *Sidewinder II* or *Sidewinder III.* Increased performance and range over *Sidewinder* is the goal of the *Diamondback* project.

BULLPUP

Navy is now evaluating the *Bullpup* air-to-surface missile and it will soon be introduced into fleet service as a service weapon. Prime contractor of the missile is The Martin Co. and production is underway at the Orlando, Fla. plant. Powerplant is a solid propellant rocket by Aerojet-General. Republic Aviation is working on a guidance system for *Bullpup.* Missile has canard layout with delta and trapezoidal control and stabilizer surfaces. It is 11 feet long and has a diameter of 1 foot. *Bulldog* is a larger and improved version of *Bullpup.*



Manufacturer: Martin Co.; Range: PUP-15,000 ft., DOG-25-30,000 ft.; Speed: PUP-Mach 1.8, DOG-Mach 2; Diameter: 12 in.; Span: 12 in.; Guidance: self-contained navigation system; Powerplant: (1) Aerojet-General; Status: advanced development.



The ultimate in simplicity, Navy's SIDEWINDER air-to-air infrared missile, has less than two dozen moving parts and no more electronic components than an ordinary radio.

U.S. Navy's SIDEWINDER

Sidewinder, Navy's air-to-air infrared homing missile is named after the deadly, fast-striking, desert rattlesnake which habitates the area around China Lake, Calif., where the missile was conceived and developed by the Naval Ordnance Test Station.

Designated AAM-N-7, the *Sidewinder* is operational with TacRon 46 aboard the *USS Randolph* with the 6th fleet in the Mediterranean and FitRon aboard the *USS Bon Homme Richard* with the 7th fleet in the western Pacific. Among the aircraft which are or soon will be equipped with the rocket are the F9F-8, FJ-3, FJ-4, F8U, FD-4, F3-H, F-104, F-100 and F-89.

The missile is a rugged, inexpensive weapon capable of operating against high-performance type aircraft, and can destroy enemy fighters or bombers from sea level to altitudes over 50,000 feet. It needs no complex launching equipment and is highly maneuverable at supersonic speeds. Basically a defensive weapon for the protection of men and ships from attacks by enemy aircraft, *Sidewinder* also will be employed in the air defense of the continental United States.

Because of its simplicity the missile, which has less than two dozen moving parts and no more electronic components than an ordinary radio, requires no specialized training to handle and assemble it effectively. Pilots will require little or no special flight training to effectively use *Sidewinder* in combat.

Sidewinder is 4½ inches in diameter and 9 feet long. It is positioned on the launching rack by three lugs that are slid into place. Four stabilizing fins are located on the aft section. These are about 21 inches long and 8 inches high with a swept-back leading edge 10 inches long. Four canard control fins are located about 11 inches from the missile nose and attached to the body by single pivot points. Swept-back leading edges of the canards are about 11 inches long and the trailing edge is about 6 inches. The base of each fin is about 8 inches long.

The guidance system is passive infra-red and this usually takes the missile up the tail pipe of the enemy aircraft. The guidance has been described as being so accurate as to seek and "kill" flares attached to drone wings without harming the drone itself.

The seeker occupies the first 4 inches of the missile, followed by guidance section; servo is located between control fins, followed by warhead, influence fuse and solid propellant rocket motor. The motor is 75

Ground crewmen attach SIDEWINDER AAM-N-7 to launching rack of F9F-8 COUGAR fighter. No specialized training is required to handle and assemble it effectively.



inches long, has a nozzle 7 inches long with 3-inch inside diameter. Burning time is 2 seconds.

Current kill rate of *Sidewinder* is reported to be 7 out of 10 and this is expected to be improved to a single-shot kill capability of 9 out of 10. Range at high altitude is 11,000 feet and at sea level about 3,500 feet. Contact fuses are located at tips of control surfaces. The influence fuse takes care of a miss situation detonating the missile which is lethal within 35 feet.

Sidewinder's seeker is operative from the moment of the launcher aircraft's takeoff. Control surfaces are stabilized by a small bucket-type wheel turning at a very high speed.

The idea for *Sidewinder* came from Dr. William B. McLean, technical director of NOTS in 1949. Development at NOTS included structure, aerodynamic configuration, infrared guidance, rocket motor, pilot presentation, aircraft-missile umbilical connection, launcher and test devices. All this was under surveillance of Bureau of Ordnance. Bureau of Aeronautics was responsible for the launcher and envelope.

Prime contract for *Sidewinder* production is Philco Corp. The company is producing the missile at its Philadelphia plant under a contract totalling approximately $14-million.

Other industrial concerns connected with the program are the Avion Division of the American Car and Foundry Industries at Paramus, N. J., who produced experimental missiles used in the research and development program and General Electric Co. at Utica, N. Y. which has been awarded a production contract amounting to more than $17 million.

Eastman Kodak Co. of Rochester, N. Y. and the Bulova Research and Development Laboratories of Weedside, N. Y. are also involved in the *Sidewinder* program. Eastman is reportedly doing the infra-red work.

Power plants for the missile are of the solid propellant type reported to be supplied by Norris Thermador, Hercules Power and Hunter-Douglas.

Although it is a Navy development, *Sidewinder* will be used by the Air Force. Funds have been allocated in the AF 1958 budget for purchase, presumably for use on the F-104. First firings of *Sidewinder* from the Lockheed fighter were announced a few weeks ago. F-100 and F-89 aircraft are also expected to carry *Sidewinder*.

Advanced models, *Sidewinder II* and *Sidewinder III* are reportedly in test and prototype stages, respectively.

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SPECIFIC DATA:

MANUFACTURER:	Philco Corp., General Electric Co.
MISSION:	air-to-air
RANGE:	18,000 ft.
SPEED:	Mach 2.5
LENGTH:	9 ft.
DIAMETER:	4½ in.
GUIDANCE:	infra-red
COST:	$1,000; some reports as low as $800
POWERPLANT:	solid propellant rocket
STATUS:	service



Bird is 4½ inches in diameter and 9 feet long. Current kill rate is 7 out of 10.

SIDEWINDER was developed by the Naval Ordnance Test Station at China Lake, California. Now operational with the 6th fleet in Mediterranean and 7th fleet in the western pacific.





U.S. Navy's ZUNI

Replacing Navy's World War II high velocity aircraft rocket is the recently announced *Zuni*, named after the Pueblo Indian tribe of Western New Mexico.

Zuni is a 5-inch rocket, 110 inches long and weighing 107 pounds. It has jet operated folding fins, a feature that allows an aircraft to carry four times as many rockets as they could *HVAR's*. *Zuni* carries a variety of warheads and fusing systems.

This folding fin, solid propelled weapon has been extensively tested by both BuOrd and the Fleet Operational Development Board, and is now approved for operational use. It has twice the velocity of the HVAR of World War II fame.

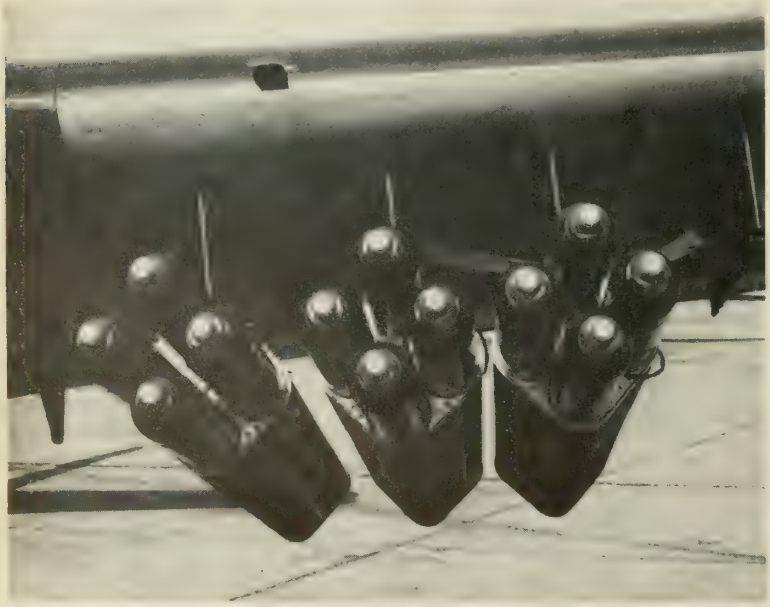
The new rocket will be used on high-performance fighter and attack-type aircraft for both air-to-air and air-to-ground firing. As an air-to-ground weapon it will be highly effective against tanks, pillboxes, gun emplacements, trains, ammunition and fuel dumps and small ships. Its high velocity and short time to target promise a high kill potential in air-to-air combat.

The *Zuni* launcher, mounted on the aircraft's wing, holds four rockets and is used for transporting and storing the rockets as well as launching. Launchers are jettisoned after firing.

The elimination of the normal packing case is expected to result in considerable time savings. *Zuni* is also designed for air-to-surface applications.

The unguided rocket generally has good static stability and reports indicate that *Zuni* is no exception. Detailed performance figures, however, are not yet available. In guided rockets, on the other hand, one must allow for a large displacement of controls to maintain a given flight path or to change direction. With relatively low static stability, they enjoy a high maneuverability rate.

Zuni's solid propellant rocket motor powers it at speeds in the vicinity of Mach 3. Cost of each rocket has been reported as $150. It was developed by the Naval Ordnance Test Station, China Lake, Calif. for the Bureau of Ordnance.



ZUNI is folding fin, solid propellant rocket, designed for fighter and attack-type aircraft, for air-to-air and air-to-surface attack. Expendable launcher holds four rockets.

• • •

SPECIFIC DATA:	-
MISSION:	air-to-air & air-to-surface
SPEED:	Mach 3
WEIGHT:	107 lbs.
LENGTH:	110 in.
DIAMETER:	5 in.
POWERPLANT:	solid propellant rocket
REMARKS:	
STATUS:	Quantity production

REMARKS:
air-to-air, air-to-surface, developed by Naval Ordnance Test Station for Bureau of Ordnance.

Sparrow I is a supersonic air-to-air missile operational in the fleet. It was developed by the Bureau of Aeronautics at the Naval Air Missile Test Center at Point Mugu, Calif., and the Sperry Gyroscope Co.

Described as a powerful deterrent against attack by jet bombers and fighters, it is about 12 feet long, weighs about 300 pounds, and is powered by a solid propellant rocket motor.

Guidance signals deflect the missile's wings and direct it to intercept the target, even under evasive action. The *Sparrow I* weapon system is versatile, permitting effective attacks against high and low altitude targets flying singly or in groups.

Guidance is of the beam-rider type directed by the launching aircraft. The complete system is manufactured by Sperry Gyroscope Co. and the rocket motor is made by Aerojet-General. Speed of *Sparrow I* is about Mach 3 and range is 5 to 8 miles.



McDonnell DEMON armed with a formidable array of SPARROW I air-to-air missiles.

U.S. Navy's SPARROW I

Official designation of *Sparrow I* is AAM-N-2.

The deadly accuracy of the missile has been demonstrated by hundreds of missile launchings against drone targets. Successful attacks have been completed against high speed jet aircraft and against other missiles.

Operational squadrons have been assigned to carriers. Additional carriers of both Atlantic and Pacific fleets, including the super-carrier *Forrestal*, will be equipped with squadrons armed with *Sparrow I*.

Sparrow I contracts of more than $50 million were awarded Sperry for the missile guidance radar and test equipment and for production of the missiles at the Sperry Farragut Co. in Bristol, Tenn.

Sparrow I systems are on the Chance Vought F7U-3M *Cutlass* with fleet units operating both from carriers and shore and with a night-fighter squadron of the Marines employing the Douglas F3D-2M *Skyknight*.

Sparrow II missiles were developed by Douglas presumably for use on the Douglas F5D which was cancelled. The *Sparrow II* has an active homing system with a radar dish behind a blunt nose. Control surfaces are trapezoidal rather than delta-shaped as in *Sparrow I* and *III*. Some reports have been heard that the Royal Canadian Air Force will use *Sparrow II* to replace the *Velvet Glove* missile.

Sparrow III missile is a Raytheon development and has been ordered into production at the Sperry Farragut plant under direction of Raytheon. Retouched photos indicate that *Sparrow II* is about the same size as *Sparrow I*. The Raytheon guidance system is said to be completely automatic in operation. Raytheon has a $60 million production contract for the missile and is reported to be working on two still more advanced models.

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SPECIFIC DATA:

MANUFACTURER:	Sperry Gyroscope Co.
MISSION:	air-to-air
RANGE:	5 mi.
VELOCITY:	Mach 3
WEIGHT:	280 lbs.
LENGTH:	8.25 ft. ex booster 11.75 ft. including booster
DIAMETER:	0.5 ft.
SPAN:	2.25 ft. (has smaller tail fins also)
COST:	$10,000
STATUS:	service

REMARKS:

SPARROW-II, officially known as the XAAM-N-3; length is said to be 4.2 ft. with weight 300 lbs.



SPARROW I missile system is combat-ready. Fighters armed with SPARROWs are equipped with airborne guidance gear developed by BuAer and Sperry Gyroscope to direct missiles.

U.S. Navy's TORPEDOES Mark 27, 37, and 43

The first modern guided missile was World War II's sonar-guided torpedo. Even though it worked solely underwater, it fit the definition of a guided missile and beat its airborne cousins by some years.

With designations like Mark 27, Mark 37 and Mark 43, World War II and present operational torpedoes have speeds ranging from 20 or 30 knots to 45 knots. Generally speaking, electrically powered torpedoes were slower but gave off no tell-tale wake and were thus more silent. Steam torpedoes or gas generator-turbine powered units reached higher speeds but gave off both visual and audible wakes. Generally speaking, the practical operational range of the torpedo was considered to be 10,000 yards.

The World War II electric torpedo used a conventional lead-acid battery. Silver cell batteries (Zn-alkali-Ag202) are up to six times lighter and five times smaller than lead-acid batteries for the same output. Primary batteries such as the magnesium sea-water-silver chloride are even lighter and smaller and are considered for torpedo use.

For the higher speed, longer range torpedoes, total energy requirements are such that thermal power plants must be used. A wide variation in performance is achievable, depending upon the propellant combination. Because of their relatively high performance and their potentially wakeless exhaust products, hydrogen peroxide-hydrocarbon systems have been widely used.

Use of either carried fresh water diluent or free sea water diluent is necessary in turbine propulsion systems in order to decrease the operating temperatures. The use of sea water, although significantly increasing the performance per unit of carried expendables, poses serious salt problems.

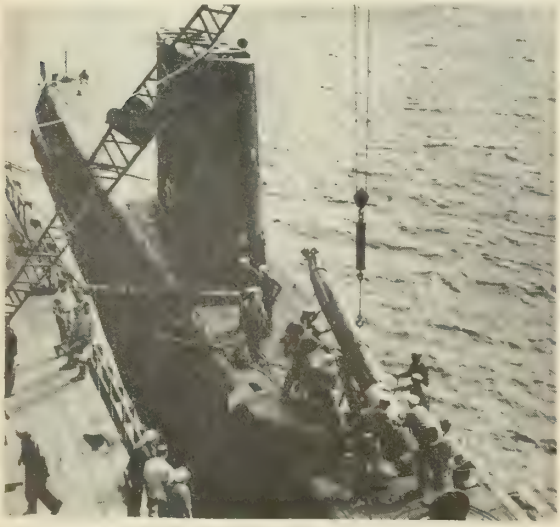
For reciprocating engine power plants, no diluent is necessary. Copious quantities of sea water are required, however, to cool critical engine parts.

However, underwater warfare appears on the verge of a technological revolution. Noisy, bubble-forming cavitation, a major problem of high-speed underwater flight, appears about to be overcome by more close emulation of the hydrodynamics of a fish. Propulsion systems under study now include not only the gas turbine but hydroducts (ramjets) and pure, conventional rockets as well. An Aerojet-General test torpedo utilizing one of the latter propulsion systems has done 155 knots underwater in captive runs. At speeds of this order, the fact that it is noisy and can be readily detected by conventional sound gear diminishes in importance. Even if the torpedo is detected, the vessel attacked would scarcely have adequate time for evasive action.

One problem, however, of large noise levels emanating from the torpedo itself is that of interference with the missile's own sound-based guidance system. However, recently highly successful work with the detectability of sounds in the very low frequency ranges may make it possible to tune guidance gear so that it will ignore its own self-made noise.

One view of the torpedo of tomorrow might be as follows: Its body will be made of magnesium, plated to provide a smooth high gloss finish. Its detection and homing gear will be acoustic; will have a range of well over 100 miles if necessary; and will concentrate in the ultra-low frequency ranges. Its speed may be anywhere from 150 knots upwards. Its propulsion system will consist of a hydroduct (ramjet) whose "combustion" products are solubles, thus leaving no visible wake. Hydrodynamically, it will be near-perfect, providing means of pressure equalization (boundary layer control), perhaps with ducts to feed in or draw off water as necessary. Its range may be anywhere from ten to several hundred miles. Its warhead will be either nuclear or with conventional explosives.

In addition, there are several projects now under way—some in the feasibility study stages; others under actual development—that involve transitional concepts where the missile starts out underwater and then becomes airborne, or vice versa.





U.S. Navy rightly can claim to be the producer of the first guided missile. Future underwater missiles may have speed of 150 knots.

U.S. Navy's TERRIER & TARTAR

A slim, needle nose weapon, *Terrier* is designed to intercept aircraft at longer range and higher altitudes than anti-aircraft guns, and under all weather conditions. A contract for about $29 million has been awarded to Convair at Pomona, Calif., for production of guidance and control units of the missile. Convair, prime contractor, participated in the engineering of *Terrier,* which was developed for the Bureau of Ordnance under technical direction of the Applied Physics Laboratory, Johns Hopkins University.

Now in operational use, *Terrier* is installed on the cruisers *USS Boston, USS Canberra,* destroyer *USS Gyatt* and will be used on many other destroyer-frigate type vessels.

The "coke handling" system for launching *Terrier* is a product of Northern Ordnance, Inc., Minneapolis. Solid propellant power plant is by Aerojet General. It is launched by a booster and is beam-rider guided.

Terrier is 13 feet long, 27 feet long with booster. It is about one foot in diameter, has a fin span of 4 feet, weighs about 3,300 pounds. Speed is 1,500 miles per hour, range about 20 miles, ceiling 60,000 feet. Cost is about $62,000. Effectiveness has been reported at 80 per cent.

Terrier II is reported to be twice the size of *Terrier I* and will have radar homing guidance to supplement shipboard beam-rider direction. Radome of Corning Glass Works Pyroceram will withstand temperatures of 2,400°F.

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SPECIFIC DATA:

MANUFACTURER:	Convair
MISSION:	Surface-to-air
RANGE:	20m
SPEED:	Mach 2.5
LENGTH:	15 ft.
DIAMETER:	1 ft.
SPAN:	4.1 ft.
GUIDANCE:	Reeves beamrider
POWERPLANT:	(1) Aerojet General SPR (1) Aerojet General SPR booster (14 ft.)
ALTITUDE:	60,000 ft.
STATUS:	early production

REMARKS: surface/ship-to-air, anti-aircraft missile. Replacing TERRIER I; now in use on cruisers and one destroyer—will be installed on 4 more ships by 1959, 13 by 1960 and 22 by 1961, when it is replaced by TARTAR.

Tartar is a surface-to-air guided missile about three-fourths the size of *Terrier.* Prime contractor is Convair and the solid propellant rocket motor is supplied by Allegany Ballistics. *Tartar* will be used on destroyers and other small vessels.

Rear Adm. John H. Sides has said that *Tartar* will also be used in secondary batteries of large ships. He reported that it outperforms the original *Terrier* and will replace five-inch batteries. Adm. A. A. Burke, Chief of Naval Operations, said *Tartar* should be cheaper than *Terrier.*

Convair's Pomona, Calif., plant has the *Tartar* contract for engineering and production under Bureau of Ordnance. In March this year contracts were let for construction of eight destroyers which will be equipped with the missile. Bureau of Ordnance has asked for $32 million in fiscal 1958 for production of the *Tartar.* This is $19 million more than received this year.

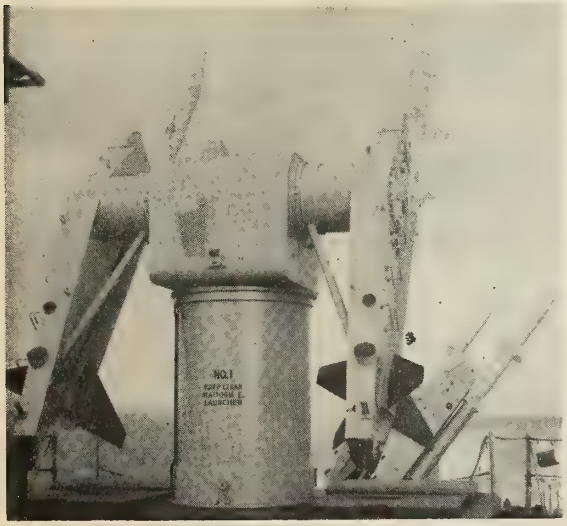
In recent hearings before the House Defense Appropriations Subcommittee Rear Adm. Frederic Withington, Chief of Bureau of Ordnance said, "I am committed to have this weapon completely ready for destroyers in the 1957 building program. As I have told the committee, this is a considerable gamble. I hope we will make it but I cannot guarantee it."

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SPECIFIC DATA:

MANUFACTURER:	Convair
MISSION:	surface-to-air
GUIDANCE:	beamrider with homing head
STATUS:	development
POWER PLANT:	(1) SPR

REMARKS: surface ship-to-air, anti-aircraft missile; essentially a refined and improved TERRIER, smaller in size; scheduled to be standard armament on destroyers and secondary armament on capital ships by 1961.





The deadly Terrier, supersonic Navy surface-to-air missile was fired experimentally in November 1954 from the Navy's USS Mississippi.



U.S. Navy's REGULUS I

Regulus I is the first in a series of surface-to-surface missiles developed and manufactured by Chance Vought. Its name is taken from a star in the constellation Leo. Regulus also was a popular name in the middle ages for a snake that was supposed to kill by its hiss.

The *Regulus I* resembles a swept-wing jet fighter, 33 feet long, span of 21 feet, diameter about 4½ feet. Take-off weight is 14,520 pounds, speed is about 600 miles an hour and range is 600 miles maximum.

Designated SSM-N-8, the missile was developed in 1948 by Chance Vought under the sponsorship of the Bureau of Aeronautics. It was designed for launching from submarines, surface ships, and shore bases. Launching equipment can be installed in a short period of time on several types of vessels at relatively low cost with only slight modification to the ship.

Tactically it will be used by Marines against appropriate land targets.

Although the assault missile and certain other configurations will employ a drone version of *Regulus I*, tactical employment will also include those techniques and guidance systems associated with the operation of all-weather, distantly controlled guided missiles. This makes it possible to utilize *Regulus I* in various ways without the expense and effort of designing and procuring a separate one for each function.

At the end of 1956 Chance Vought's Dallas plant had orders totaling $26 million for production of *Regulus I* which had been in service as the Navy's first operational attack missile since 1955.

The non-recoverable version of *Regulus I* is capable of delivering a nuclear warhead over a range of hundreds of miles guided by a built-in electronic brain built and developed by Stavit Engineering and Advance Industries, Inc. The recoverable version, equipped with a retractable landing gear, flies pilotless missions and lands intact. As many as 16 flights have been made by a single *Regulus I*. The drone designation is KDU-1.

Powerplant of *Regulus I* is an Allison J33-A-18A turbojet delivering

REGULUS I on a test flight. It travels at about 600 miles an hour with a 600 mile range. Successful flights with wing pods have been made extending range to a possible 1000 miles.



4,600 pounds of thrust. The missile is launched by two Aerojet-General solid propellant 1,000-pound thrust ATO rockets or by means of a steam-driven catapult.

Regulus I is directed by a command guidance system, parts of which are manufactured by Bendix, Ultrasonics Corp., Sperry Gyroscope, Motorola, Inc., and Bell Aircraft.

The subs *Tunny* and *Barbero* carry the *Regulus I* in round watertight hangars on their decks just aft of the conning tower. In a matter of minutes after surfacing, crews can roll out and launch the missile. The sub *Halibut* will have an internal hangar for both *Regulus I* and *Regulus II*. It will be the first nuclear submarine specifically built for missiles.

Airframe subcontractors for *Regulus I are* R. H. Osbrink and Bendix. Subcontractors on the powerplant are Goodrich and Goodyear.

Fuselage of *Regulus I* is cylindrical with heavy gauge skins wrapped on bulkheads, stringers and longerons. Wings consist of cast magnesium outer panels on a conventional built-up center section. Wings fold for shipboard stowage. There is no horizontal tail—both pitch and roll control being exercised through ailavators on the trailing edge of the wing.

Missile is launched from a short rail launcher in which it rests on four slipper fittings. Launching boost is from two rockets which accelerate the missile to flying speed in a little over 2 seconds. Rocket cases and slippers are ejected after launch.

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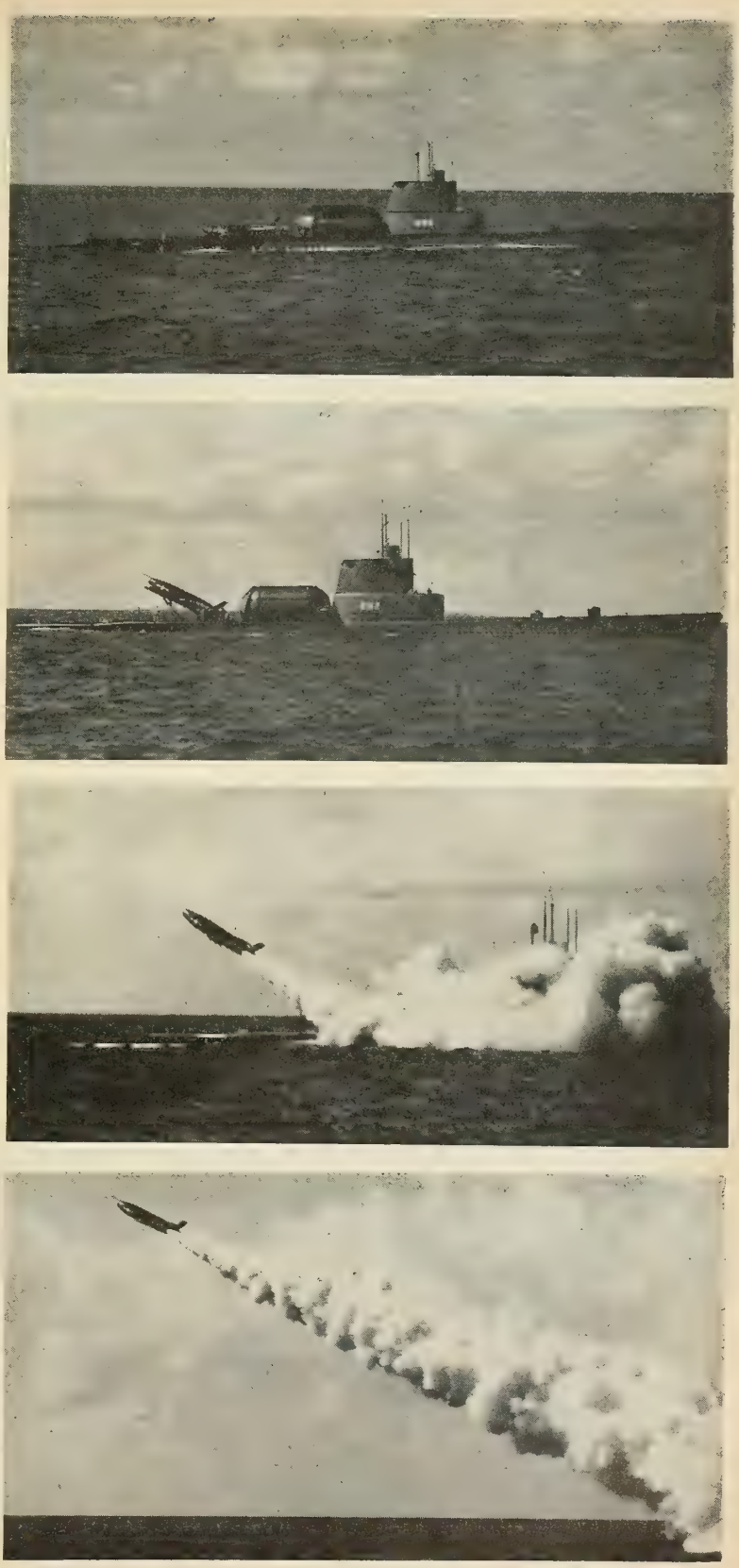
SPECIFIC DATA:

MANUFACTURER:	Chance-Vought Aircraft Inc.
MISSION:	surface-to-surface
RANGE:	600 mi.
SPEED:	600 mph
WEIGHT:	14,520 lbs.
LENGTH:	32 or 33 ft.
HEIGHT:	9.5 ft.
DIAMETER:	4.5 ft.
SPAN:	21 ft.
STATUS:	service

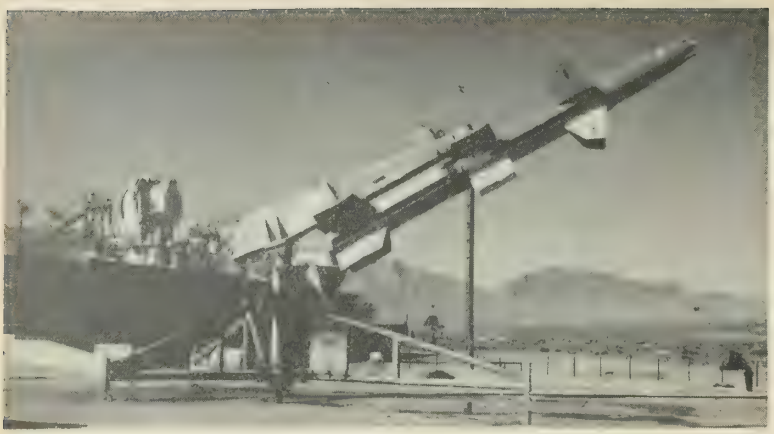
REMARKS:

several models known; one is experimental model with parachute recovery device; second, training model; third, a gunnery target; all have wheels; tactical model does not have wheels or recovery mechanism

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The subs TUNNY and BARBERO carry the REGULUS I in round watertight hangars on their decks just aft of the conning tower. Photos show launching sequence aboard USS TUNNY. Missile is moved from hangar to launch platform, is prepared for firing, and soars skyward leaving clouds of smoke from its solid propellant booster rockets.



Slated for arsenal of the U.S. Fleet next year TALOS can, in addition to its surface-to-air mission, be used against ship and shore installations. Army may use it for air defense.

U.S. Navy's TALOS

Talos, Navy's long-range, surface-to-air missile, will be added to the fleet early in 1958. It will form the major armament of the light cruiser *USS Galveston* now undergoing conversion to a guided-missile cruiser at the Philadelphia shipyard. A year later cruisers *USS Little Rock* and *USS Oklahoma City* will be armed with *Talos* and will rejoin the fleet. The first nuclear-powered cruiser *Long Beach* will also have *Talos* armament.

Talos is capable of delivering a high explosive or nuclear warhead at any altitude that airplanes can fly and far beyond the range of human vision. Originally designed for shipboard installation, *Talos'* great range and accuracy have drawn the interest of Army as ground defense weapons in the Continental Air Defense system.

Production of *Talos* is underway at the Naval Industrial Reserve Ordnance plant, Mishawaka, Ind., operated by Bendix Aviation, for the Bureau of Ordnance. Bendix received a $27 million contract early this year.

The missile is the second to come out of the *Bumblebee* program at the Applied Physics Laboratory for Johns Hopkins University.

Talos is powered by a McDonnell ramjet engine which operates after the missile has been boosted to supersonic speeds by a solid rocket motor. The ramjet using zip fuels is reported to propel the missile at Mach 3.5.

The guidance is a mechanical brain called steering intelligence system which insures great accuracy. When within lethal range of target a proximity fuel detonates the warhead.

Rear Adm. J. H. Sides said "*Talos* is larger than *Terrier* and has longer range. It will reach out into zones now covered by interceptors." The missile is being evaluated at White Sands Proving Ground, N. Mex. In development tests it killed a drone at 25 miles with a direct hit. That was in 1954 and Navy says missile has undergone considerable improvement since.

Talos is essentially a 20-foot hollow tube 30 inches in diameter. Inside the open nose is a blimp-shaped diffuser which channels air past burners producing tremendous thrust. Four maneuverable stubby wings at mid point and four tail fins control its course and stabilize its flight. Fins are said to be made of fiberglass. Those made of magnesium were rejected.

McDonnell, in addition to supplying the ramjet engine, also builds the airframe. Radio Corporation of America is reported to be involved in development of ground and airborne radar beam-rider systems.

Reports early this year have indicated that *Talos* might become the standard antiaircraft missile of NATO. It is known that the British would like to procure the missile for replacing RAF interceptors.

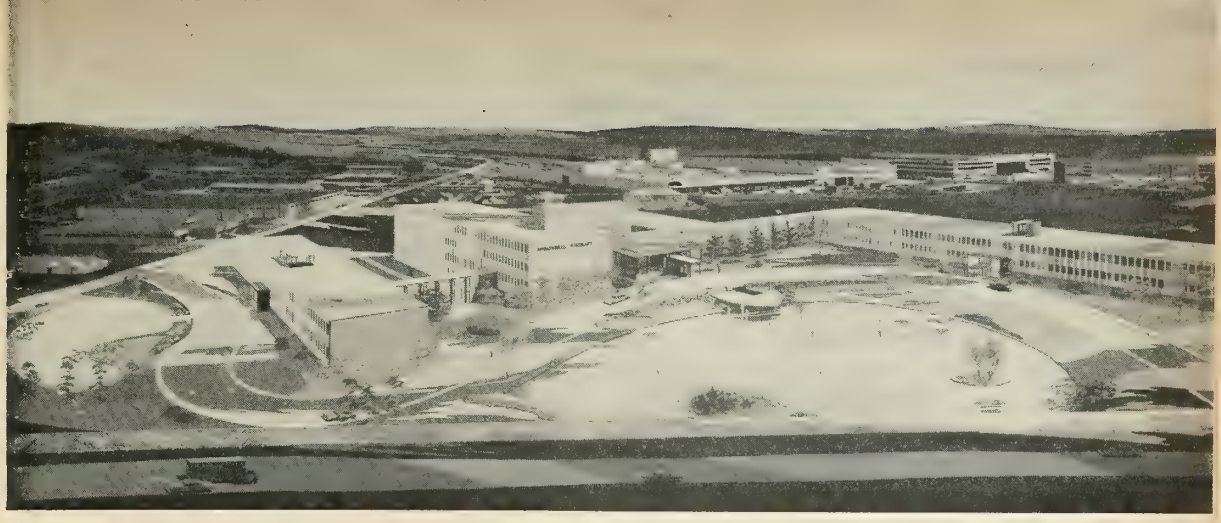
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SPECIFIC DATA:

MANUFACTURER: Bendix Aviation Corp. (prime)
McDonnell Aircraft Corp. (airframe)
MISSION: surface-to-air
SPEED: Mach 4
WEIGHT: 3,000 lbs.
LENGTH: 15 ft.
DIAMETER: 18 in.
SPAN: 4.1 ft.
GUIDANCE: Bendix beamrider plus radar homing
POWERPLANT: (1) McDonnell 18" ramjet
(1) SPR booster
ALTITUDE: 75,000 ft.
GROUND CHECK-OUT: Reeves Instrument
STATUS: limited production for test
REMARKS: surface-to-air, inner-defensive, anti-aircraft missile; land-based version recently transferred from USAF to Army cognizant under Wilson's "roles and missions" decree; future status uncertain in view of Army emphasis on NIKE HERCULES



TALOS, boosted by solid propellant rocket, gathers speed as it roars from launcher. It will lock on target and when within lethal range a proximity fuse detonates the warhead.



U.S. Navy's TRITON

Triton is the third generation of sub-launched surface-to-surface missiles on the drawing boards. It is powered by twin McDonnell ramjets and is in the 1,500-mile range class with speeds of Mach 3.5 and a self guiding system. It is expected to reach 80,000 feet in altitude.

Triton will use zip fuels. Solid booster rockets will launch the missile and push it to supersonic speeds when the ramjets take over. *Triton* is designed to fit *Regulus* launching and storage equipment.

Bureau of Ordnance is asking $2.6 million more than last year for *Triton* development. No figure on last year's sum has been reported.

Like *Talos, Triton* is an outgrowth of the *Bumblebee* program at the Applied Physics Laboratory at Johns Hopkins University. McDonnell is the prime contractor and also supplies the ramjet engines. Bendix has been reported as supplying the fuel control equipment and the inertial guidance system is by Kearfott.

In charge of the *Triton* program at McDonnell is Chief Engineer Ben G. Bromberg. His office is responsible for development and testing of guided and unguided missiles which the company has under contract and to involve new missile designs. McDonnell currently has some 750 engineers in the Missile Engineering Division. This is about 20% of the total number employed by the company. The missile engineers are moving into a new $1 million office building—the first of a series to form an "engineering campus" at the St. Louis facility.

Navy Missile Director Rear Adm. John Clark probably referred to *Triton* when he stressed the need for continued ramjet missile development because of the many problems still facing the ballistic missile before it could become a precision weapon. The ramjet missle, he pointed out, is fully controllable and can be guided in flight.

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SPECIFIC DATA:

MANUFACTURER:	McDonnell Aircraft Corp.
MISSION:	surface-to-surface intermediate range aerodynamic cruise
RANGE:	1500 mi.
SPEED:	Mach 3.5
WEIGHT:	20,000 lbs.
LENGTH:	47 ft.
DIAMETER:	57 in.
GUIDANCE.	inertial by Kearfott Co.
POWERPLANT:	ramjet plus booster
ALTITUDE:	80,000 ft.
STATUS:	development

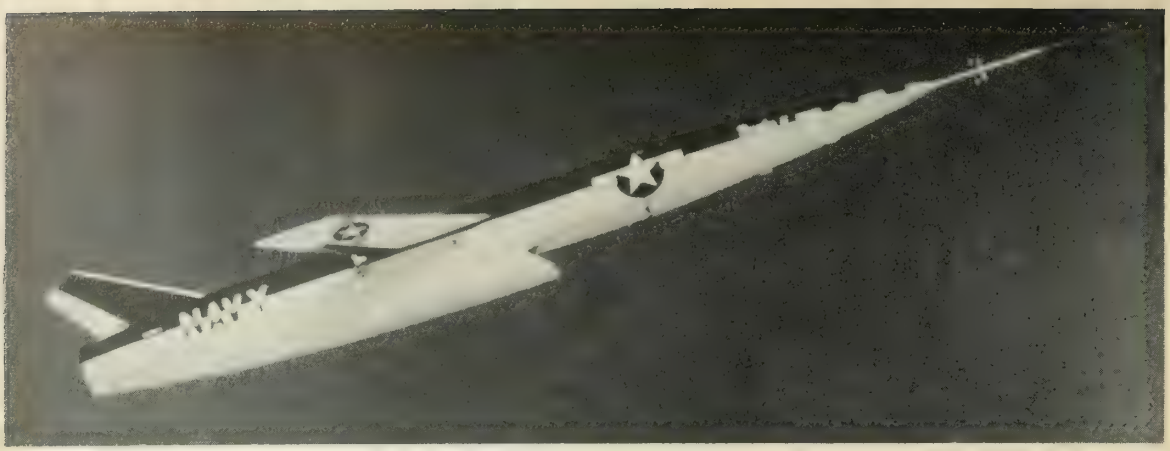
REMARKS: surface-to-surface, pilotless, aerodynamic tactical weapon, BUMBLEBEE (John Hopkins) project: a scaled-up TERRIER



Dr. Ben Bromberg (second from left), Chief Engineer of McDonnell's Missile Engineering Division, and his staff have TRITON development responsibility. $2.6 million additional '57 funds for TRITON.



Design engineering section of Missile Engineering Division's new $1 million St. Louis facilities. MED has some 750 engineers. This is about a 20% slice of McDonnell's total engineers employed.



U.S. Navy's REGULUS II

Regulus II is planned as the operational successor to *Regulus I*. Its increased speed and altitude make it a more effective weapon.

The second version of the Chance Vought surface-to-surface missile is designated SSM-N-9 and is designed for launching from a submarine, or ship and may also be used as a land-base weapon. It is 57 feet long, about six feet in diameter and has a wing span of about 20 feet. It may carry a nuclear warhead.

Test models of the missile are powered by the Curtiss-Wright J65 jet engine but production missiles carry the General Electric J79 turbojet—the same engine that powers the supersonic Lockheed F-105, Convair B-58 and Grumman F11F-1.

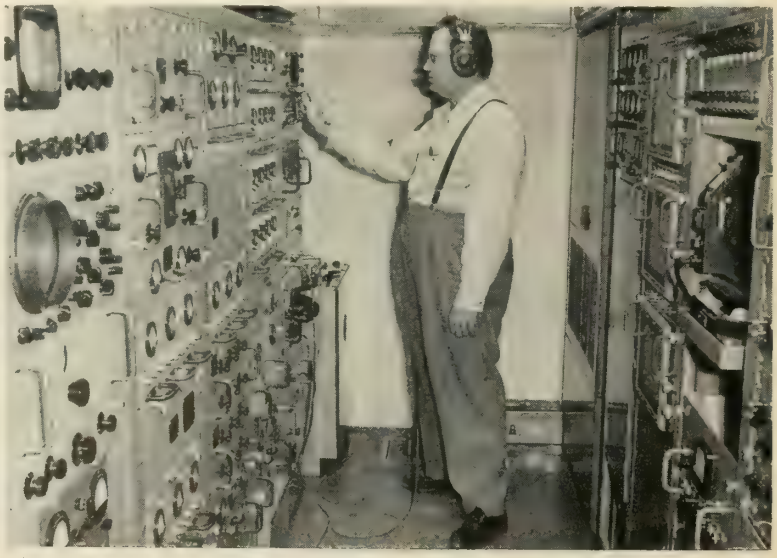
Regulus II features a fixed canard stabilizer just aft of the nose, swept wings with extremely sharp leading edges and a very large belly air scoop. There is no horizontal tail stabilizer. Test vehicles are equipped with tricycle landing gear for recovery. They are reported to land at about 250 knots on full afterburner with both elevons down.

Navy first showed the *Regulus II* in early March. By that time some 13 test flights had been carried out at Edwards Air Force Base, Calif. Six of these tests were reportedly with the same missile. At last report test models were averaging four flights each.

Rear Adm. John E. Clark said that the range of *Regulus II* is less than the IRBM range of 1500 miles. Most observers say the missile is capable of 1000 miles.



Regulus II test vehicle designed by Chance Vought for the U.S. Navy is recoverable.



Telemeter van used for checking telemeter gear in Regulus II during flights. Regulus II has flown at more than 1½ times the speed of sound and above 50,000 ft.

Reason for the relatively limited range of the *Regulus II* when compared to the 5000-mile range of the similar-sized subsonic *Snark* is that a heavy accent has been placed on speed.

The large air scoop beneath the belly of *Regulus II* has a smaller shovel-shaped inlet located above the engine intake. Air from this small scoop is led through large open ducts built into the fuselage and emptied beneath each wing from slots marked "boundary layer exits." This arrangement is believed to serve as a supersonic fillet to minimize wing-fuselage interference.

Regulus II's altitude has been announced as above 50,000 feet. Speed is Mach 5 to Mach 2.

Compared to *Regulus I*, the later missile is longer by 26 feet, about twice as heavy, and costs about twice as much.

When launched from a surfaced submarine or other ship the missile is boosted by a single, large, solid-propellant motor manufactured by Aerojet General. By the time the missile becomes operational, Navy will have two submarines converted as *Regulus II* launchers.

Firestone Tire and Rubber has a contract for installation of the launching on the subs *Grayback* and *Growler*. Guidance for the *Regulus II* is by Sperry. *Regulus II* is usable from the same ships and submarines that handled *Regulus I*. At present many carriers, four cruisers, in addition to subs, carry *Regulus I*.

Air Force has indicated interest in the *Regulus* missiles as air-to-surface weapons. There have been reports that a *Regulus I* was fired from a B-52. Before firing, the missile was carried in the bomber's big bomb bay.

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SPECIFIC DATA:

MANUFACTURER: Chance Vought Aircraft Inc.

MISSION: surface-to-surface aerodynamic cruise

RANGE: 800-1000 mi.

SPEED: Mach 1.5

WEIGHT: 12 tons

LENGTH: 57 ft.

DIAMETER: 6 ft.

SPAN: 20 ft.

GUIDANCE: radio command by Stavid Engineering Co.

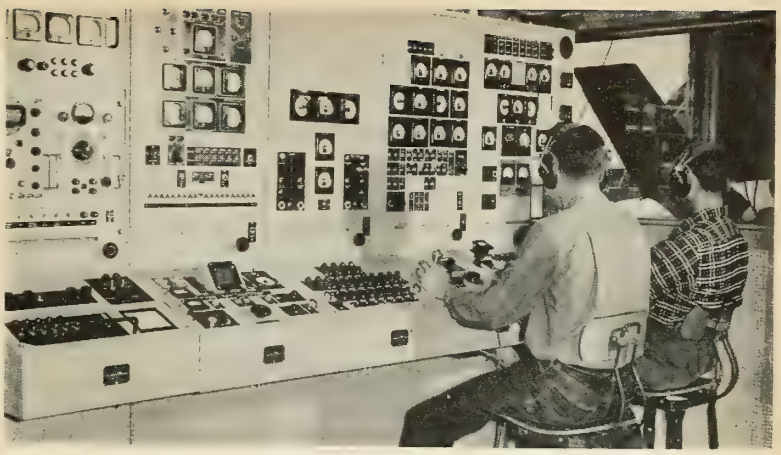
POWERPLANT: first eight a/c-Wright J65s; all others—GE J79s

ALTITUDE: 50,000 ft.

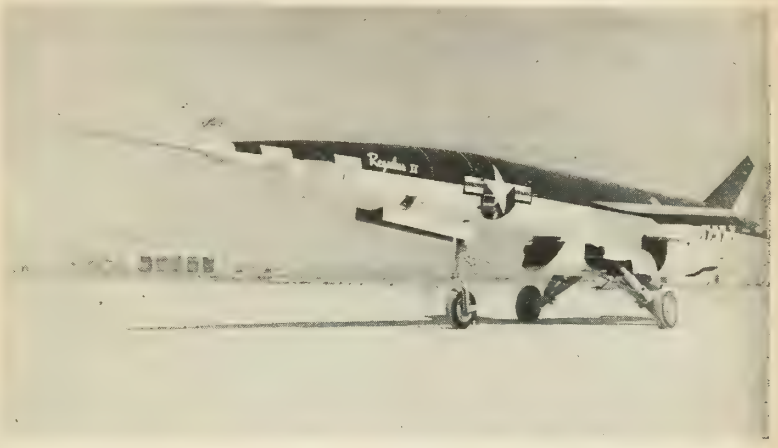
LAUNCHER: (2) Aerojet 4-second solid powder boosters

STATUS: early production

REMARKS: surface-to-surface, air-breathing, aerodynamic tactical missile, shore/ship/submarine launched; Firestone Tire and Rubber Co. Guided Missile Division, Monterey, to design, build, test and install launching system for submarines



Check out of controls for Regulus II is conducted from this Tunny Panel, which is identical to the control system used for Regulus missile in submarine.



Ground view of the supersonic Regulus II at Edwards Air Force Base, California. Missile can carry nuclear warhead and is designed to be launched from subs as well as surface vessels.



Regulus II test vehicle is powered by a J65 turbo jet engine. Later versions will employ the more powerful J79 power plant. This vehicle also employs boundary layer control.

U.S. Navy's POLARIS

Named for the North Star, *Polaris* will be the Navy's first underwater-launched intermediate range ballistic missile. It will be substituted for the *Jupiter* which the Navy was planning to use its ballistic missile system.

Polaris is described as a stubby weapon with a range of 1,500 miles maximum. One of the reasons mentioned for selection of *Polaris* instead of going along with *Jupiter* was the shipboard handling problem. *Polaris* will have a solid rocket motor instead of the *Jupiter's* liquid motor.

Prime contractor for the *Polaris* is Lockheed Aircraft Corp. at Sunnyvale, Calif. Aerojet-General is working on the rocket and recent reports that the company had fired the largest solid-propellant motor yet, indicates that the company is well along on the project.

Massachusetts Institute of Technology and General Electric are working on design and development for a fire control system for the missile. Loewy-Hydropress Division of Baldwin Lima-Hamilton Corp., has a $2,-million contract to build a ship-motion simulator for use in developing *Polaris*.

Other contractors include Westinghouse-Sunnyvale for design and manufacture of experimental seagoing handling and launching systems including development of various mechanical and electrical systems for launching *Polaris* from subs and surface vessels.

The inertial guidance package for *Polaris* is slated to undergo acceleration and vibration tests at the Supersonic Navy Ordnance Research Track at China Lake, Calif.

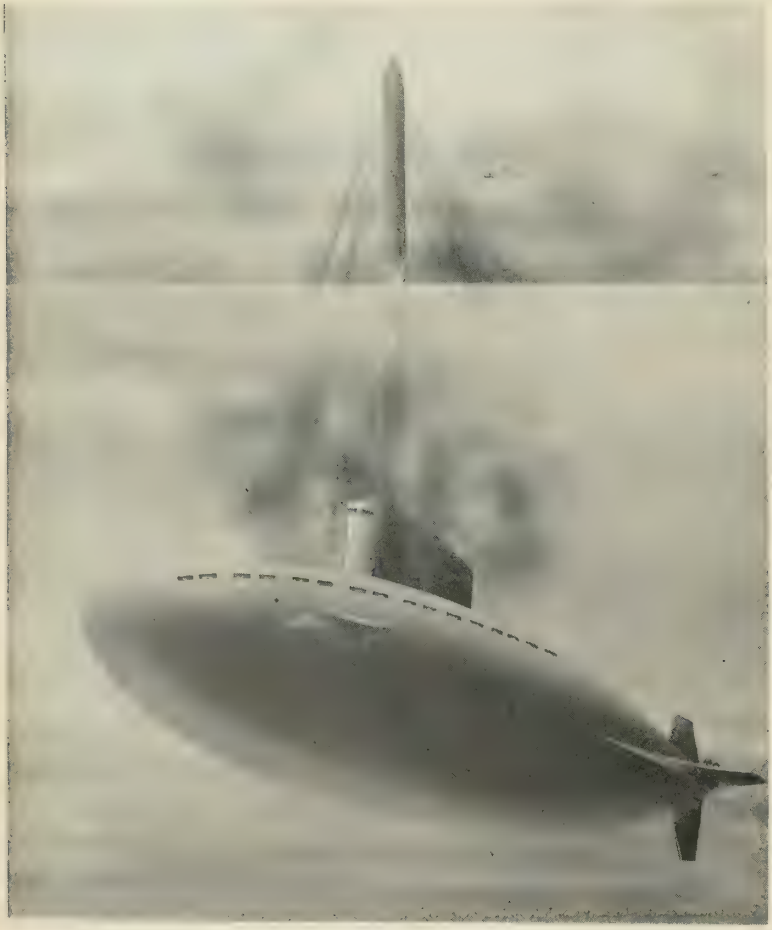
Rear Adm. W. F. Raborn, director of the *Polaris* project, said that *Polaris* will be a supporting weapon in future task forces which will be built around the aircraft carrier. Tactical mission would be to beat down fixed-base air and missile defense to pave way for carrier strikes. Infinite number of launching points will make it impossible for the enemy to pre-plot the *Polaris* trajectory.

Admiral Raborn said that the present *Polaris* program provides for a limited number of missiles plus a new nuclear submarine capable of launching the weapon.

Navy has requested $68 million for the missile and related equipment in fiscal 1958.

Some truly sophisticated underwater vessels are being planned by the Navy. These submarines are nuclear-powered guided missile carriers built to launch the solid-propellant, high-punch, intermediate-range *Polaris* Fleet Ballistic Missile. The submarines—possibly two prototypes on order at first—are part of the *Polaris* project.

Possibly the biggest missile and most complex weapons system the Navy has ever attempted, the *Polaris* will be a high-energy solid-propellant stubby 40-50-foot missile approximately 100 inches in diameter. Range is believed to be between 800 and 1500 miles. The atomic warhead in the *Polaris* will be quite sizable, 1000 pounds might be a fair guess.



The POLARIS is described as a stubby missile with a range of 1500 miles. Special submarines using ALBACORE-type hull are understood to be planned for the Navy's fleet ballistic missile. The Polaris can also be launched from surface ships. Lockheed is prime contractor.

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SPECIFIC DATA:

MANUFACTURER:	Lockheed MSD
MISSION:	surface to surface IRBM
RANGE:	1500 mi.
DIAMETER:	100 in.
LENGTH:	40-50 ft.
GUIDANCE:	GE/MIT to be based on Ship Inertial Navigation System (SINS) developed by Dr. Draper
STATUS:	early development
REMARKS:	fleet ballistic missile. to be ready "in 5 years" for operational use.

U.S. Air Force's MIGHTY MOUSE

For years America's only operational air-to-air rocket was the reliable 2.75 inch, folding fin unguided *Mighty Mouse* or FFAR.

The rocket uses a proximity fuse, and has fins that fold out at launch. Some airplanes, for example the F-89 and F-94C, carry them in wing tip pods to improve dispersion, firing about twelve in a quarter of a second. Other planes, such as the F-86, fire them in single volleys of 24, leaving the aircraft at 200 miles per hour.

The F-89D can carry 104 of these 2.75 rockets and fire them electronically. A T-110 rocket gun has been developed to fire the *Mighty Mouse*.

The principle of the small rocket is that of the shotgun. If enough of them can be fired into a given volume of space, it is almost mathematically impossible that an intruding aircraft or target banner can escape at least one hit even with contact fuses. Since each one packs a wallop equivalent to a 75 mm cannon shell, it is doubtful whether even the largest aircraft could survive a single hit.

FFAR measures 48 inches in length and 18.5 pounds in weight, of which 3.5 pounds is allocated to the warhead. Powered by a double-base solid propellant, it is capable of a maximum velocity of about 2,600 feet per second (Mach 2.7 at altitude), and has a burnout time of about 1.5 seconds. The thrust during this brief period is about 800 to 900 pounds and the acceleration is on the order of 50 gravities. Exact performance specifications remain classified, however.

Aerojet-General Corp., Azusa, Calif., manufactures the rocket motor and ingenious folding fin assembly; Hunter Douglas Aluminum Co., Riverside, Calif., which makes the tubes, and Heintz Manufacturing Co., Philadelphia, which produces the warheads. Colson Corp., Elyria, Ohio, produces rocket motor assemblies.

In the past, components for the 2.75-inch rocket have been produced by at least eight other manufacturers. Manufacturing motors were Tecumseh Products Co., Tecumseh, Mich.; Muncie Gear Works, Muncie, Ind.; Landers, Fary and Clark Co., New Britain, Conn. Tubes were provided by Reynolds Metals Co., Phoenix; Aluminum Company of America at New Kensington, Pa., and Norris Thermador Corp., Los Angeles, while C. D. Cottrell Co., Westerly, R. I., manufactured the warheads.

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SPECIFIC DATA:

MANUFACTURER:	Aerojet General Corp. Hunter Douglas Aluminum Co. Heintz Manufacturing Co. Colson Corp.
MISSION:	air-to-air
VELOCITY:	2,600 ft. per sec. (Mach 2.7 at Altitude)
WEIGHT:	18.5 lbs., 3.5 lbs. warhead
LENGTH:	48 in.
DIAMETER:	2.75 in.
GUIDANCE:	aimed
COST:	$65
STATUS:	service

REMARKS: most available, most ready, most operationally effective air defense weapon available today



Simple missile used by the Air Force is the 2.75" MIGHTY MOUSE, standard weapon for our jet fighters. Missile is easy to handle.



MIGHTY MOUSE packs a wallop equivalent to a 75 mm cannon shell. It is doubtful if the largest aircraft could survive single hit.

U.S. Air Force's FALCON



FALCON aerodynamic configuration is termed pseudo-canard. The forward wings are fixed with steering accomplished by control surfaces placed at trailing edge of stabilizers.

The Hughes GAR-1 *Falcon* is the Air Force's only operational air-to-air missile.

The weapon is smaller than Navy air-to-air weapons, weighing only about 100 pounds and having a range of about five miles. It utilizes a Thiokol solid-propellant motor which produces enormous thrust for a very brief interval, accelerating the missile to a velocity of more than Mach 2.

The *Falcon* is part of a complete weapon system developed by Hughes Aircraft Co. for the Northrop F-89 and Convair F-102A and F-106A interceptors. Approximately 1200 pounds of fire control equipment is carried in the aircraft to support the missile.

Its aerodynamic configuration is termed pseudo-canard. "Pseudo" because although having a typical canard configuration with small forward fins and large aft supporting surfaces, the forward wings are fixed and steering is accomplished by control surfaces hinged to the trailing edge of the stabilizers. A round nose fairs into a cylindrical fuselage which terminates in a boat-tail housing the exhaust nozzle of the rocket motor.

Guidance is by radar impulse generated by the interceptor. The system has all-weather capability and is entirely automatic. It has been reported that Hughes is working on an infra-red version of the *Falcon*. The Air Force is planning, however, to buy the Navy's *Sidewinder IR* air-to-air missile for use with its Lockheed F-104A interceptors.

This will probably mean mixed payloads on a single interceptor. A combination of radar and infra-red guided missiles on the same mission would greatly enhance the possibility of a successful hit. Everything that can be done to out-guess or confuse the enemy's airborne system of countermeasures serves to increase the probability of a successful mission.

Hughes Aircraft Co. says of the *Falcon*: "The GAR-1 has the lethal capacity to stop any bomber dead in its tracks and can do it frequently enough to have resulted in drone bomber targets being one of the major items of project expense. They have been a costly item even though *Falcon* test missiles carry payloads of telemetric equipment rather than warheads."

Cost of the GAR-1 was estimated at $19,000 a copy last year, but it was expected that the cost would drop. Early this year, Hughes announced the GAR-1D *Falcon* which incorporates aerodynamic improvements and can reach greater altitudes than the earlier model.

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SPECIFIC DATA:

MANUFACTURER:	Hughes Aircraft Co.
MISSION:	air-to-air
RANGE:	about five mi.
VELOCITY:	Mach 2 plus
WEIGHT:	(take-off) about 110 lbs.
LENGTH:	77.8 in.
SPAN:	20 in.
PROPULSION:	Thiokol SPR motor 6,000 lbs. thrust



The air-to-air FALCON is the smallest guided missile in production. Slightly over 6 feet in length and weighing 110 pounds, it is powered by a Thiokol solid propellant propulsion unit. GAR-1D FALCON (above) incorporates aerodynamic improvements over earlier model.

U.S. Air Force's BOMARC

Most potent of all air-defense missiles now in advanced development is the IM-99 *Bomarc* pilotless interceptor. Boeing Airplane Co. is developing and producing the weapon for the Air Force.

Unlike the *Nike* and *Terrier* missiles, which are "point" defense weapons, the *Bomarc* is an "area" defense weapon. Its maximum capability may only be realized when the Air Force places the gigantic SAGE information gathering and computing system in full operation.

The Boeing weapon is powered by a pair of Marquardt ramjet engines plus an Aerojet liquid-propellant booster mounted in the tail. It has a gross weight of 15,000 pounds and an estimated range of 200-300 miles. Range may be increased through the use of high-energy synthetic fuels like pentaborane.

Bomarc takes off in a vertical attitude on the thrust of its booster rocket and climbs at supersonic speeds until the ramjets ignite. This occurs before booster burnout, so the total acceleration of the weapon climbs sharply as the upward flight progresses. At its programmed altitude of about 60,000 feet, the missile levels off sharply and proceeds toward its target at speeds in excess of Mach 2.5.

Boeing was awarded a production contract for the *Bomarc* IM-99 interceptor missile on May 16. The initial production contract was for $7,109,195.

Bomarc was revealed as a long-range ground-to-air interceptor missile designed to operate at "extreme" altitudes and supersonic speeds, with outstanding range characteristics.

In a series of successful firings against high-flying "drone" airplanes over the Atlantic Ocean, the *Bomarc* has proved itself an excellent interceptor weapon, according to the Air Force.

Bomarc will be operated by the Air Defense Command from bases where its range capabilities may be fully utilized. Because of its range, the IM-99 is known as an "area defense weapon" as opposed to short-range anti-aircraft missiles known as "point defense weapons."

The new missile is launched vertically by a liquid fuel rocket engine When it reaches a speed suitable for ramjet operation, the rocket cuts out as twin ramjet engines take over to provide supersonic cruise flight. The ramjets are slung on struts beneath the slim, cylindrical *Bomarc* fuselage.

Design of the *Bomarc* missile is based on technical background acquired in Boeing's "GAPA" (Ground to Air Pilotless Aircraft) program of the late '40s. These early missiles, of which 112 were test-fired, ranged up to 16 feet in length and reached speeds of 1500 miles an hour. Their operating altitudes ranged from 6,000 to 80,000 feet.

Speeds and altitudes of the *Bomarc* have not been officially revealed by the Air Force. Armament of the 15,000 pound weapon is described as a "high explosive warhead".

Individual IM-99 flights have been carried out since early autumn 1952. Piloted airplanes fitted with *Bomarc* electronic guidance system components have also been used in the test program, with the pilot cutting out the guidance system and pulling away from the collision course as the *Bomarc*-guided plane closed in on its target.

These extensive tests provided proof of components and supplied background for recent firings in which the Boeing IM-99 missiles were operated as part of an integrate weapon system, seeking out and intercepting "drone" bombers far out over the Atlantic.

The *Bomarc* missile is being assembled in Seattle. More than 70 per cent of the missile is subcontracted.

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SPECIFIC DATA:

MANUFACTURER:	Boeing Airplane Co.
MISSION:	Surface-to-air
RANGE:	200-300-mi.
SPEED:	Mach 2.5-3



BOMARC, trailing flame from its Aerojet liquid propellant booster engine, leaves launch pad at Patrick Air Force Base, Fla.

WEIGHT:	15,000 lbs.
LENGTH:	46 ft. 8 in.
DIAMETER:	3 ft.
SPAN:	18 ft.-2 ft.

GUIDANCE: SAGE programmed, with radar homing (developed by Westinghouse Air Arm)

POWERPLANT: (2) Marquardt ramjets-28 in. (1) Aerojet General LPR booster

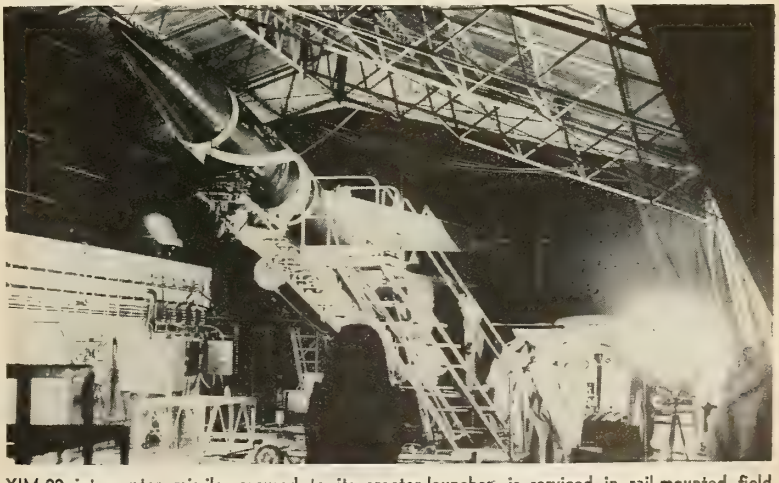
ALTITUDE: over 60,000 ft.

GROUND CONTROL: Remington Rand ERA 1103 computer system

GROUND ALIGNMENT AND CHECK-OUT: test equipment "GO-NO-GO" by Farnsworth Electronics

STATUS: quantity production, for IM-99

REMARKS: surface-to-air, pilotless, aerodynamic cruise interceptor missile. XIM-99 is experimental missile; YIM-99 is service model to be tested by Air Force.



XIM-99 interceptor missile, secured to its erector-launcher, is serviced in rail-mounted field shed in preparation for launching. XIM-99 flights have been made since autumn 1952.



U.S. Air Force's RASCAL

The GAM-63 *Rascal* is a liquid-propelled air-to-surface rocket missile under development for the Air Force by the Guided Missiles Division of Bell Aircraft Corp.

Purpose of weapons like the *Rascal* is to permit bombers to stand off from their targets when delivering nuclear weapons in order to avoid lethal combinations of defending interceptors and anti-aircraft missiles in the target area.

Rascal is undergoing flight testing against simulated targets at Holloman Air Development Center, New Mexico, where it has been launched from B-47, B-36 and B-50 bombers.

The division has made continued refinements in the *Rascal's* powerplants, including the rocket thrust chambers, turbine pump, propellant valves and propellant tanks.

More than 50 rocket propellants have been evaluated in the company's laboratories during the last three years and more than 15,000 rocket thrust chamber runs have been conducted in the more than 50 test cells located at the Wheatfield plant and the nearby Bell Test Center (Air Force Plant No. 38).

An estimated 350,000 pounds of oxidizer and 100,000 pounds of fuel are consumed in these evaluation and production tests each month and the consumption is on the increase.

Nineteen of the division's test cells can be used for environmental testing of thrust chambers and complete rocket engines, with temperatures ranging from minus 65 degrees to plus 287 degrees Fahrenheit.

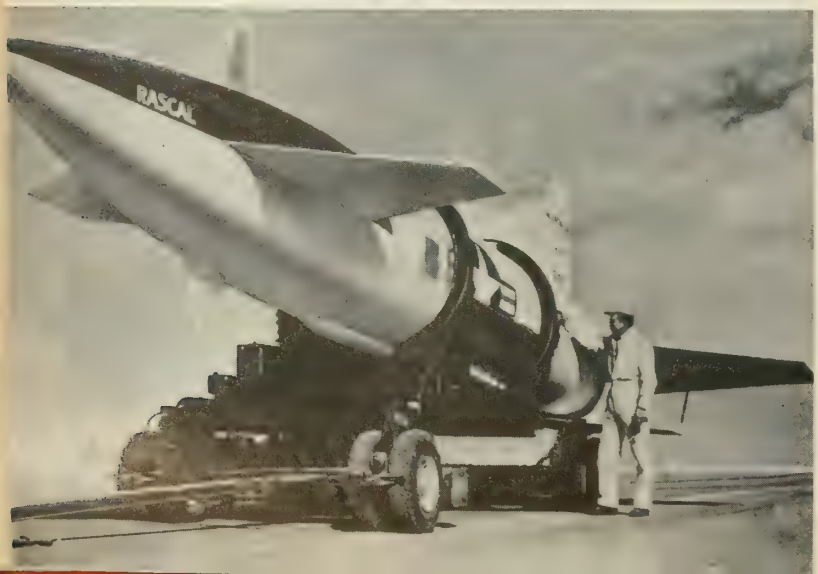
Rocket engineers have designed and developed rocket engines for five guided missiles, one of which already is operational, and are engaged in designing more powerful rocket powerplants for other military missiles and weapons systems.

Range of the *Rascal* is generally estimated at 100 miles. It utilizes a three-chambered Bell liquid-propellant rocket engine which can accelerate it to speeds of approximately Mach 1.5.

The project came under fire in the report issued by Rep. George Mahon's (D-Tex.) House Defense Appropriations Subcommittee this spring. "Investigations carried out by the Committee Staff have indicated that a reduction in the so-called 'Rascal' program is justified, and the Defense Department agrees that this particular missile is in the marginal area," the report stated.

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RASCAL, the most advanced air-to-surface missile, is undergoing flight test evaluation.



SPECIFIC DATA:

MANUFACTURER:	Bell Aircraft
MISSION:	air-to-surface
RANGE:	100 mi.
VELOCITY:	Mach 1.5-2
WEIGHT.	13,000 lbs.
LENGTH:	35 ft.
DIAMETER:	4.5 ft.
SPAN:	25 ft.

GUIDANCE: Bell command; new inertial system under development by Federal Telecommunications under Bell subcontract

POWERPLANT: (3) Bell LPR (6,000 lbs. ea.)

ALTITUDE:	launch altitude
LAUNCHER:	B-47, B-52, B-58

FLIGHT CONTROL. radio guided from mother plane

STATUS:	development

REMARKS:
40 built for test; under product improvement program; Bell awarded $22 million AMC contracts 1/29/57 for continued R&D; strategic air-to-surface.

U.S. Air Force's MATADOR

First of the Air Force's missiles to reach operational status is the TM-61 *Matador* surface-to-surface missile. It is manufactured by The Martin Co., Baltimore, and is powered by an Allison J33 turbojet engine. It can haul a 3,000-pound warhead more than 600 miles at high subsonic speeds and at altitudes of more than 35,000 feet.

The Air Force's first wing of *Matador* missiles is now operational in Germany as part of the Twelfth Tactical Air Force. It is designated the 701st Tactical Missile Wing and consists of three groups located at Bitburg Air Base, Hahn Air Base and Sembach Air Base, Germany. Each group has a tactical missile squadron responsible for actual preparation and launching of the weapon, plus a communication and guidance squadron and a support squadron.

One of the most difficult problems in operational missile units is that of sustaining the unit's combat proficiency at a high level without daily, weekly or even monthly firings. Even if there were space available for such training in Europe, the cost would be prohibitive since each *Matador*, plus its Thiokol solid-propellant booster, costs approximately $100,000.

USAF has developed an inexpensive technique for frequent and thorough tests without expenditure of the *Matador* weapons. This involves the use of a T-33 jet equipped with a Matador-type guidance system. The T-33 simulates the *Matador*, with the pilot responding to visual and audio signals—but no verbal communication—from the ground controller. Just like the missile, the manned aircraft is led through the various phases of a mission, including warhead arming, predumping procedure and simulated dumping on target. On a single flight, a T-33 assigned to the 701st Tactical Missile Wing may execute as many as three simulated *Matador* flights.

The Air Force recognizes that simulated flights, despite their great importance in maintaining proficiency, are not the whole answer. Therefore, the launching teams of the 701st are scheduled to make one actual firing each year at the firing range in Libya managed by the 17th Air Force at Wheelus AFB, near Tripoli.

There are 36 launching teams in the wing. Three versions of the *Matador* have developed to date. The first, TM-61A, was equipped with a single MSQ radar guidance system which requires line-of-sight communication with the missile at all times in order to effect positive control. The 701st has a network of radar tracking stations in Germany to keep tabs on the missile and inform the ground controller of its course and position at all times.

All squadrons of the 701st have now been converted to the TM-61C, which uses in addition to the MSQ system, the so-called "Shanicle" system. Though no details of the system were released by the Air Force, it is believed that "Shanicle" is the first known use of the "HYPERBOLIC grid system." This involves the creation of a grid pattern of radio waves by two separate transmitters.

The missile is pre-programmed to follow a set sequence of augmented and diminished signals across the pattern to target itself. This has the advantage of eliminating the possibility of human error on the part of the ground controller as well as providing positive control over much greater range than the line-of-sight MSQ, but it is not clear to what extent Shanicle might be subject to enemy jamming.

Latest version of the *Matador* is the TM-61B. This is several feet longer than the A and C models and has a clipped wing. It is said to have greater range as well as an improved guidance system requiring no assistance from the ground once the missile is launched. This suggests a number of guidance systems, such as inertial, celestial, a combination of both or a radar transmitter within the missile to determine position.

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MATADOR (TM-61A and C)—
SPECIFIC DATA:

MANUFACTURER:	Martin Co.
RANGE:	more than 600 mi.
VELOCITY:	high subsonic
LENGTH:	39 ft., 8 in.
HEIGHT:	9 ft., 9 in.
WINGSPAN:	27 ft., 10 in.

GUIDANCE: MSQ radar control, first used in Korea to direct fighter-bomber strikes. Also, on C model, the Shanicle system.

ALTITUDE:	more than 35,000 ft.

PROPULSION: Booster; Thiokol solid-propellant rocket; 52,000 pounds thrust for two seconds Sustainer; Allison J33 turbojet of 46,600 lbs. thrust.

PAYLOAD:	3,000 lbs.
STATUS:	service

MATADOR B (TM-61B)—
SPECIFIC DATA:

MISSION:	surface-to-surface aerodynamic cruise
RANGE:	over 600 mi.
SPEED:	Mach 0.9
WEIGHT:	13,800 lbs.
LENGTH:	45 ft. 10 in.
DIAMETER:	54 in.
SPAN:	28 ft. 9.5 in.
HEIGHT:	9 ft. 9 in.

GUIDANCE: radar; celestial (?); inertial-depending on model and modification

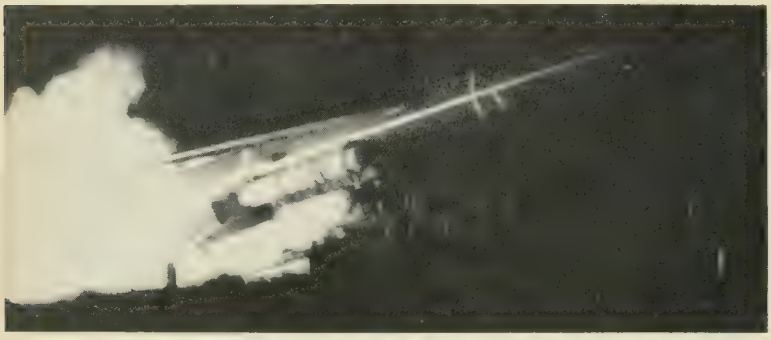
POWERPLANT:	Improved Allison J33 (4,600 lbs.) Booster Thiokol SPR, 52,000 lbs.
ALTITUDE:	45,000 ft.
STATUS:	In production
PAYLOAD:	3,000 lbs.
REMARKS:	Tactical, aerodynamic surface-to-surface, Nuclear warhead

The latest version MATADOR, TM-61B, is longer and has shorter wings than models A and C.





Below, Northrop's SNARK takes off from Patrick AFB at night. Two solid propellant boosters accelerate the missile from its zero-length launching rail. Missile cruises (above) at Mach 0.94. Range is 5000 miles. Warhead is delivered at supersonic speed.



U.S. Air Force's

SNARK

The Northrop *Snark* is the first intercontinental missile to go into production for the Air Force. It is expected that units of the Strategic Air Command will commence training with the weapon in the last quarter of 1958. It is a joint development of Northrop and the Air Research and Development Command. The SM-62 has demonstrated its long range and accuracy in numerous successful flights over the sea test lanes reaching southward across the Atlantic from Patrick Air Force Base.

It is a high altitude, swept-wing, single-engine, jet-propelled intercontinental guided missile equipped to guide the missile over extended distances for long-range delivery of a nuclear warhead. It has slim fuselage lines, with high-aspect ratio wings mounted near top and slightly forward of center of fuselage. Tail consists only of a vertical stabilizer. Engine air intake is located below underside of fuselage and aft of wing junction. The thin wings have a "sawtooth" leading edge. Elevons—combination ailerons and elevators—on the trailing edge of the wing eliminate the need for a horizontal tail.

Snark is powered during cruise flight by a Pratt & Whitney J-57 turbojet engine. Aerojet-General Corp., Azusa, Calif., supplies the zero-length solid-propellant boosters which hurl it



The Aerojet solid propellant boosters for the SNARK each yields 33,000 pounds of thrust. Zero-length launcher rail measures 29 feet.

into the air without a take-off run.

Snark is designed for a range of more than 5,000 miles; at least one flight of about 2,000 miles has been recorded. It utilizes a combination inertial and celestial guidance system. The weapon is subsonic, reportedly cruising at a speed of about Mach .9. Its altitude capability is probably better than 50,000 feet during the latter portion of its mission. It carries out its mission despite night or inclement weather. It can fly above turbulent weather and over long distances.

The *Snark* can be "zero" launched from a stationary or mobile launcher in a relatively small area. The missile and launcher are extremely mobile and can be flown to any point in the world within a few hours. The missile and its ground support equipment are normally transported by C-124 Globemaster aircraft and can be set up in launch position within a short time after its arrival at a given destination.

The mobile launcher, also developed by Northrop to Air Force strategic considerations, is a basic element of advanced ground support equipment which enables the *Snark* to aim its nuclear punch from a hidden site in any type of terrain—mountains, desert, or Arctic wastelands.

Designated the SM-62, the weapon is viewed by top Defense Department officials as a competitor to the North American *Navaho*. Former Deputy Defense Secretary Reuben Robertson, Jr., told the House Defense Appropriations Committee earlier in the year: "We view the *Snark* and *Navaho's* approach in the air breathing intercontinental group quite similar to the *Thor* and *Jupiter* competitive situation. One of them is going to win that race and one of them should be put into inventory."

Asked why the Defense Department continued its support of *Snark* in the face of opposition from Eger V. Murphree, former special assistant to Defense Secretary Charles Wilson for guided missiles, and other high military officials, Robertson replied:

"We felt that this is a weapon in which we had such a large investment that we should go ahead and get it in the inventory. While it has its disadvantages in being subsonic, it will probably have quite an accurate guidance system as now visualized, a very good CEP (circular error probability)."

The advantage of the air breathing missile is that, compared to its ballistic competitor, it's relatively slow in its terminal dive on target and is thus more readily susceptible to detection and interception. This advantage accrues to the ballistic missile only so long as an effective anti-ICBM missile has not been developed. But once such a counter-system is operative, the ICBM is then without further recourse. In the ballistic phase of its trajectory it cannot take evasive action and furthermore, it cannot—because of the conditions of reentry—employ countermeasures, electronic or otherwise.

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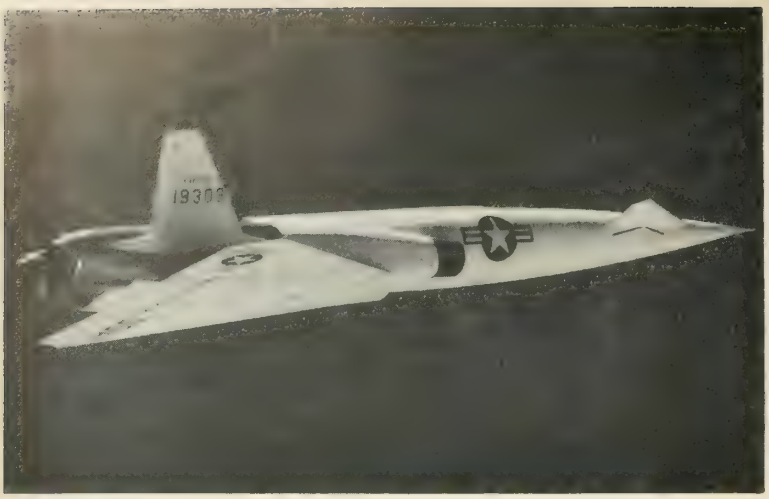
It's a big bird with plenty of room, auxiliary power supplies and full control over its course. SNARK can take evasive action, on-board countermeasures can be easily altered.

SPECIFIC DATA:

MANUFACTURER: Northrop Aircraft Inc.
MISSION: surface-to-surface aerodynamic cruise
RANGE: 5000 mi.
VELOCITY: Mach 0.94
WEIGHT: 35,000-38,000 lbs.
LENGTH: 74 ft.
HEIGHT: 15 ft.
DIAMETER: 4.5 ft.
SPAN: 42 ft.
GUIDANCE: Northrop MK I celestial and inertial (wt. 1,000 lbs.)
POWERPLANT: P&W J57 (11,000 lbs.) has also used Westinghouse J40 and Allison J71
ALTITUDE: 60-75,000 ft.
LAUNCHER: (2) Aerojet SPR Boosters (33,000 lbs. ea.) and zero-length rail (29 ft.)
STATUS: pre-production and redesign
REMARKS: intercontinental aerodynamic cruise missile



Operational tests using SNARK-type missiles against combined defenses show that this kind of missile is difficult to intercept. SAC is expected to employ SNARKs in 1958.



U.S. Air Force's

NAVAHO

Most ambitious of all air-breathing surface-to-surface missiles presently under development is the North American XSM-64 *Navaho*, an intercontinental weapon.

The Air Force-financed missile is undoubtedly the largest of all air-breathers. Although no photographs have been released, the weapon is said to be aerodynamically similar to the X-10 turbojet-powered test vehicle. Flight tests with the X-10 were completed early this year.

Navaho employs two large Curtiss-Wright ramjet motors for cruise power, plus a liquid-propellant rocket booster system for take-off and acceleration to the high Mach number necessary to permit the ramjets to ignite. *Navaho* models now under test employ a set of three North American rocket engines of 120,000 pounds thrust each for initial boost; the projected SM-64 production *Navaho* is scheduled to use a single North American motor of more than 400,000 pounds thrust. Latter is in advanced development.

As in the case of most missile developments, preliminary firings of the *Navaho* have been plagued with failures for trivial reasons. First XSM-64 aborted at 9,000 feet when a rate control gyro failed.

On the second firing attempt at Patrick, the big missile tore away part of its launching apparatus on take-off, causing the booster to lose power and the vehicle to fall in the sea. The third trial in April was a complete failure because the rocket boosters quit firing after two seconds in response to a wild signal from within the missile.

One of the interesting features of the XSM-64 is the fact that it incorporates retractable landing gear. A dead-stick landing procedure was worked out with the X-10, and it is hoped that some of the vehicles can be recovered for re-use.

The Defense Department last year struck out the Air Force's request for funds to support the *Navaho* in fiscal 1958, forcing the airmen to "reorient" the program to make fiscal 1957 funds last as long as possible. A decision on whether to go ahead with the *Navaho* will probably come in the fall.

The outlook now does not appear favorable for the weapon. Funds are expected to remain extremely tight, and top Defense officials have made it known they believe one air-breathing intercontinental missile is enough for the Air Force.

But many things might happen to change top-level Defense thinking, and test work on the *Navaho* will continue. North American believes its warhead-accuracy potential is much greater than that attainable with the intercontinental ballistic weapons, and that *Navaho* therefore has a specific place in the nation's future arsenal.

Whatever the *Navaho's* ultimate fate, its development has contributed more to advance the state of the missile art in the U.S. than any other single factor. It has introduced North American to many brand new fields of activity, including development of most of the engines which will be used in future ballistic missiles.

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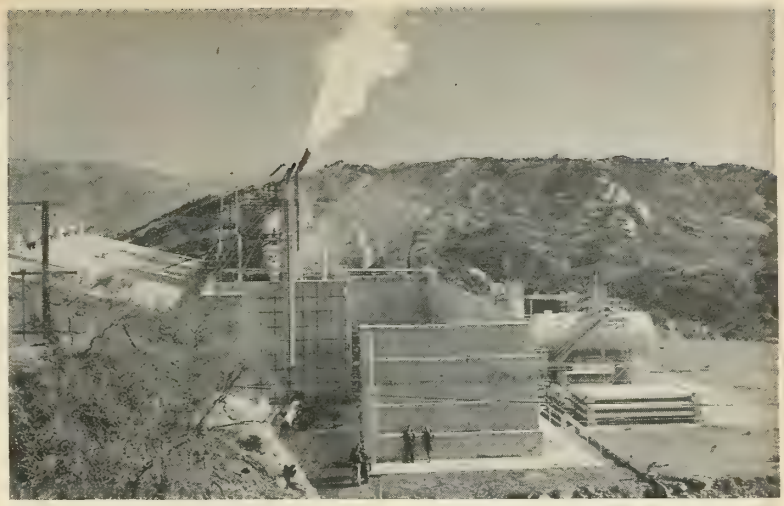


X-10, North American Aviation's unmanned test vehicle for AF's SM-64 NAVAHO intercontinental strategic aerodynamic cruise missile has concluded its flight test program. Launched by rockets and powered by turbojets, X-10 has provided much valuable research and development data for other missile programs. NAVAHO will use modern ramjet sustainers.

SPECIFIC DATA:
MANUFACTURER: No. American Av'n., Inc.
RANGE: more than 5,000 mi.
WEIGHT: (estimated) 200,000-300,000 lbs.
VELOCITY: Mach 3-3.5
ALTITUDE: 70,000-80,000 ft.
PROPULSION:
Booster; Three NAA liquid-propellant rocket engines, total thrust of 360,000 lbs.
Sustainer; Two Curtiss-Wright ramjet engines
STATUS: development
MISSION: surface-to-surface aerodynamic cruise

U.S. Air Force's

THOR



THOR's 135,000-pound thrust power plant is made by Rocketdyne Division of North American Aviation, Inc. Here, rocket engine gas generator flares at Rocketdyne test facility.

The WS-315 *Thor* is the Air Force's entry in the Intermediate Range Ballistic Missile race. Its main competitor is the Army's *Jupiter* IRBM, although the Navy is also developing an IRBM of its own, the *Polaris* Fleet Ballistic Missile.

The *Thor* is a single-stage weapon powered by a North American liquid rocket engine with a thrust of 120,000 to 140,000 pounds. Its range is 1500 miles. Its airframe is manufactured by Douglas Aircraft Co. Inc., while A.C. Spark Plug Div. of General Motors Corp. is developing the guidance. The nose cone undoubtedly features the blunt shape proposed by the National Advisory Committee for Aeronautics in 1953.

First test firings of new missiles are almost invariably fraught with surprises and failures, and the *Thor* has proven to be no exception. On its first launching trial, foreign matter contaminated the oxygen system and the engine failed to receive sufficient LOX to maintain combustion. Thrust deteriorated when the vehicle was a couple of feet in the air and it sagged back to the launching stand, broke in two and exploded.

On the second firing attempt, the USAF entry in the IRBM race appeared to wander off course and was detonated after a flight of 38 seconds. Later it was said that the range safety officer's radar monitoring system was out of kilter and that the missile was actually on course. But the third launching effort was even more frustrating; four minutes before launching, an electrical short circuit started a fire and the missile burned up without ever leaving the ground.

Despite these unhappy experiences, the Air Force is confident it will be able to prove out the *Thor* and that the weapon—or most of it—will ultimately be selected for quantity production for operational use with the Strategic Air Command.

Early this year, the Air Force announced it had awarded a $67,500,000 contract to Douglas for fabrication and testing of *Thor* airframes. The period covered by the contract was not disclosed, but the Air Force did say that none of the funds covered development of engines, guidance or other components.

The Air Force has frequently pointed out that the *Thor* development program is a considerable bargain because many of the components of the rocket missile are being developed for its big brothers, the *Atlas* and *Titan* Intercontinental Ballistic Missiles.

The Air Force was given complete operational control over all surface-to-surface land-based missiles with a range of more than 200 miles by the terms of Defense Secretary Charles Wilson's memorandum on roles and missions last November. Principal effect of the memorandum was to turn the Army's *Jupiter* over to the Air Force, for further financing and operational use.

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SPECIFIC DATA:

MANUFACTURER: Douglas Aircraft Co.
Mission: surface-to-surface IRBM
RANGE: 1500 mi.
VELOCITY: Mach 10
GUIDANCE: radio-inertial by AC Spark with assistance from Bell Telephone Labs
POWERPLANT: (1) NAA LPR (135,000 lbs.)
STATUS: prototype firings ($67.5m for continued development)
REMARKS: Intermediate range ballistic missile; nose cone—GE; warhead—Sandia Corp.



THOR engine under test? The canyons rock with the thunder of captive power. This Rocketdyne test stand is high in the Santa Susana Mountains, 35 miles from Los Angeles.



First official photos of Atlas test base. Atlas missile systems are checked out in this test tower in Sycamore Canyon, a secluded military reservation N.E. of San Diego.

U.S. Air Force's ATLAS

The WS-107 *Atlas* is the first of the most ambitious line of missiles yet attempted—the Inter-Continental Ballistic Missile, ICBM. It is officially described as being in pilot production at Convair's Astronautics Division at San Diego, Calif. The missile is now in the test flight stage, being fired from Patrick AFB, Fla. Components and systems test other than engine run-up is conducted at Convair's special facility on the ocean side of Point Loma, San Diego Bay, Calif.

Convair Div. of General Dynamics Corp. initiated work on the *Atlas* project as far back as 1947. With Air Force funds, it developed and fired several models of the MX-774 liquid-propelled missile to determine the feasibility of a gimballed motor. During the lean days of the late 1940's, it carried the project with its own funds.

It was not until about 1953 that the feasibility of an ICBM became clear. The U.S. succeeded in detonating a true hydrogen bomb (in contrast to a hydrogen *device*), demonstrating that a warhead of titanic power could be wrapped up in the relatively small confines of an ICBM's nose section. This at once had the effect of sharply diminishing the ICBM's size as well as broadening its permissible circular error probability to limits deemed attainable with guidance equipment within the state of the art.

A second "technological breakthrough" was the discovery by the National Advisory Committee for Aeronautics that a blunt nose cone could reject 90% or more of the re-entry heat to the atmosphere by setting up a strong shock wave. This substantially alleviated cooling problems and cleared the way for the Air Force's present $1 billion a year ballistic missile effort.

No photos have yet been officially released on the *Atlas*, but several bits of information have been gleaned during the past several months regarding its probable configuration. It is understood the weapon utilizes three North American liquid-propellant engines—two boosters of about 120,000 pounds thrust and a sustainer motor of 140,000 pounds. The boosters and presumably their turbopumps and tankage are jettisonable when they burn out.

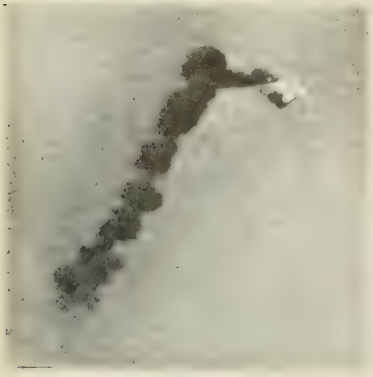
Also, the wide publicity given the precise date and time of the highly secret first firing of the *Atlas* configuration resulted in several hundred people being on hand about the land perimeter of Cape Canaveral, many of them photographers with the best in long lense equipment.

On this first firing, the 5,000-mile missile went between 5,000 and 10,000 feet before it was intentionally detonated by the range safety officer. From the appearance of the missile in flight, this apparently is what happened: The twin boosters fired properly until the missile reached between 5,000 and 8,000 feet. Then one of the liquid rocket engines apparently suffered a failure in its LOX supply. The flame went from a crisp clean yellow to a dirty orange. Black smoke belched forth. Loss of power in one of the paired engines caused a violent yaw. The missile made at least two efforts to correct for this before it was detonated.

Quite a number of pictures were taken of the missile during this period and have been published. Study of them reveals that surrounding the engine nozzles is a flare to provide directional stability. The missile has no fins as such. The pictures also reveal that the missile was not fired with its final nose cone, but utilized a fairly conventional low-drag-to-weight ratio shape instead.

The actual nose cone, rather than being sharply tapered and pointed as shown, will be very blunt with a heavy metal base probably coated with laminated plastic. It is scheduled to be attached to later test models.

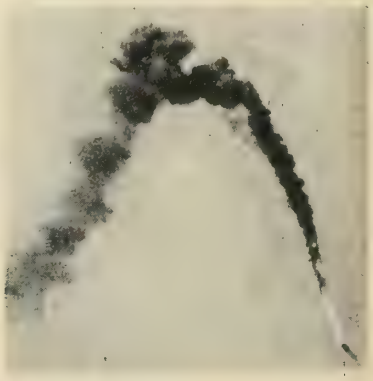
Length of the *Atlas* is something



Prototype of the Atlas ICBM was fired from Patrick AFB at Cape Caneveral last month.



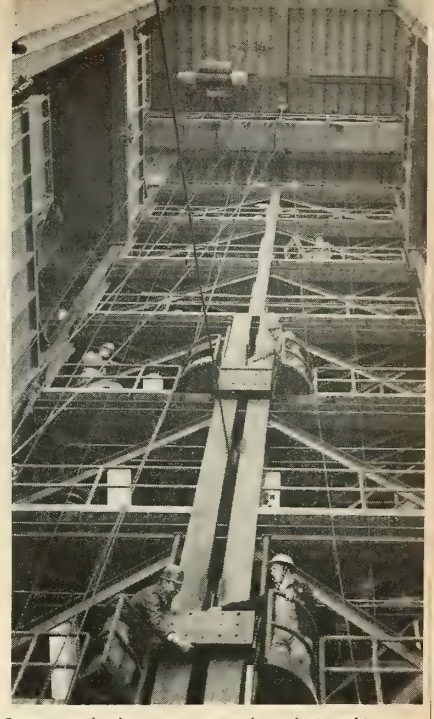
A mass of flames and spiraling at 10,000 feet the Atlas ICBM leaves a trail of black smoke.



The Patrick AFB range safety officer exploded the missile because one engine failed.



Sycamore is one of three facilities where Convair, Division of General Dynamics Corp. is testing the Atlas missile. Component testing is conducted on Point Loma in San Diego.



Systems checkouts are conducted in this huge tower at Convair's San Diego facility.

under 100 feet, and take-off weight is probably more than 200,000 pounds. Its maximum range is 5,500 miles and its apogee is about 800 miles. It will attain speeds of approximately 15,000 mph upon its re-entry into the atmosphere. To test re-entry problems with full-scale nose cones, the Air Force is using the Lockheed three-stage X-17, powered by Thiokol *Sergeant* and *Recruit* solid-propellant motors. Speeds of about 9,000 miles per hour have been achieved with this device, equal to about one-quarter of the re-entry energy of an ICBM.

Just when the *Atlas* is expected to be ready for operational use has never been disclosed publicly, but it is certain that it will be sometime after 1960 and probably later than the operational date now expected for the *Thor-Jupiter* IRBM.

Probably the most crucial problem with the *Atlas* at the present time is guidance accuracy. Most officials expect this will prove to be the toughest headache of all, and many companies have been brought into this phase of the program to work on alternate solutions. (See *Titan,* p. 162) Hinging on the answer to this question is the timetable for reduction of the Air Force's fleet of manned bombers.

Commented one Air Force wag: 'I foresee two broad periods in the ICBM program. In the first period, we can probably be sure of missing Western Europe and hitting Russia. In the second period, we can guarantee strikes within reasonable distances of specific targets. The trouble is, I can't tell you how long that first period will last, and so, I can't say when we will be able to de-emphasize manned bombers."

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SPECIFIC DATA:

MANUFACTURER: (San Diego)	Convair Astronautics
MISSION:	surface-to-surface ICBM
RANGE:	5500 mi.
SPEED:	Mach 15
WEIGHT:	over 90 tons, take-off
LENGTH:	70 ft.
DIAMETER:	body 8 ft. 6 in.; flare, 12 ft.
GUIDANCE:	original AC Spark radio-inertial system cancelled; now inertial system by Arma ($1.1 mi. contract) assisted by the Bell Telephone Labs (ground control)
POWERPLANT:	(1) NAA LPR sustainer (100,000 lbs.) (2) NAA LPR boosters (135,000 lbs. ea.)
ALTITUDE:	800 mi. peak trajectory
STATUS:	Flight Test
REMARKS:	intercontinental ballistic missile auxiliary power-AMF; thermonuclear warhead-Sandia Corp.; nose cone and re-entry body-GE.



Special trailer was built to transport the Atlas ICBM missile from San Diego to Patrick Air Force Base. Second Atlas firing is understood to be scheduled for next month.

U.S. Air Force's TITAN

The *Titan* (WS-107) Intercontinental Ballistic Missile is an alternate approach to the ICBM problem. The missile's airframe is under development by The Martin Co. in a new $20 million facility near Denver, Colo.

Aerojet-General Corp. is developing *Titan's* propulsion system. According to a recent speech by Dan Kimball, president of Aerojet, the company is working on a propulsion system for a long-range ballistic missile which includes a first-stage rocket engine of 300,000 pounds thrust at sea level, and a seven-stage engine of 60,000 pounds thrust at sea level. These engines are undoubtedly intended for *Titan*.

In configuration, the *Titan* would appear to be a tandem, two-stage missile like the Army's *Nike* or the Navy's *Terrier*. First stage would carry the weapon up to altitude before the second stage motor is ignited, as distinguished from the *Atlas* system in which all three motors are fired simultaneously on the ground.

Development of the *Titan* was ordered late in 1955 when it was decided to put the USAF ICBM program on something approaching a "crash" basis. The Martin weapon does not duplicate the Convair *Atlas*, although many of its components are common to both systems. In discussing the decision to go ahead with a second ICBM program, former Air Force Secretary Donald Quarles said last year:

"This plan enables us to conduct simultaneous development of two operational missiles, representing different technical approaches, at an estimated increase of only 10% of the cost of developing a single configuration. The decision to pursue two different approaches was prompted by the desire to assure earliest possible success in our ICBM effort."

Actually, the airframes and propulsion systems of the *Atlas* and the *Titan* appear to be so distinctly different that it is unlikely that these can be regarded as interchangeable. This may not be true of the nose cones under development for the two missiles, and it certainly is not true for the various guidance systems. Both the Special Projects Department of General Electric Co., Philadelphia, and the Research Div. of Avco Manufacturing Corp., Everett, Mass., are working on nose cones for the two missiles.

A total of seven contractors are working on guidance for the USAF ballistic missile program, but the Air Force still has not linked individual contractors to individual ballistic projects. They include: Heavy Military Electronics Div. of GE, Syracuse, N.Y.; American Bosch Arma Corp., Garden City, N.Y.; A.C. Spark Plug Div. of General Motors Corp., Milwaukee; Burroughs Corp., Paoli, Pa.; Univac Div. of Sperry-Rand Corp., St. Paul, Minn., and the Instrumentation Laboratory of the Massachusetts Institute of Technology.

Specifically these appear to be the main contractors for Martin's *Titan*. An initial USAF development contract totaling $358 million has reshaped the geographic organization of its prime airframe contractor—The Martin Co. The *Titan* program, centered by Martin in a new $10-million facility in Denver, is already outgrowing the bounds of initial planning.

As a result, a $2-million plant expansion is already in the mill. Present employment of 2,500 is expected to reach 5,000 next year.

Titan propulsion is assigned to Aerojet-General at Azusa, Calif. Prime contractor for nose cone development is Avco Manufacturing Corp. at Lawrence, Mass. with Lockheed Aircraft Corp.'s Missile Systems Division lending research support to both the *Atlas* and *Titan* nose cone R&D effort via its X-17 research project.

In *Titan* guidance, American Bosch Arma Corp., of Garden City, N.Y. is spearheading inertial guidance development and Bell Telephone Laboratories/Western Electric Co. at Whippany, N.J. is tackling radio guidance.

In addition to these prime development assignments, American Machine & Foundry Co.'s Turbo Division is developing auxiliary power units for unnamed missiles.

Two missile firms, Associated Products Corp. of Pomona, Calif. and Hallamore is also subcontractor to conbair in the *Atlas* project.

Baldwin - Lima - Hamilton Corp. holds subcontracts from Martin for *Titan* test stands and, in turn, has contracted with Beckman Instruments, Inc. to supply specialized computers. Douglas has also ordered Beckman data processing equipment to speed *Thor* research.

Burroughs Corp. holds contracts for data processing equipment in the ground control equipment for the IRBM/ICBM program. Fruehauf Trailer Co., Los Angeles plant, is building special *Thor* truck-trailers under a $15-million subcontract from Douglas.

But these are only a few of the 200 subcontractors active to date in the ICBM and IRBM in the programs.



Four static test stands are being completed at Martin's Titan facility near Denver, Colo.

The roster of the unnamed, obviously even more impressive by its numbers alone, remains to unfold.

Defense Secretary Charles Wilson recently voiced a somewhat cryptic comment about the ICBM program. Discussing the two weapons, he remarked to a Senate Committee: "The one we think is best" is probably "farther behind." Developmentwise, the *Titan* is behind the *Atlas,* so Wilson may have been expressing a preference for the former weapon system.

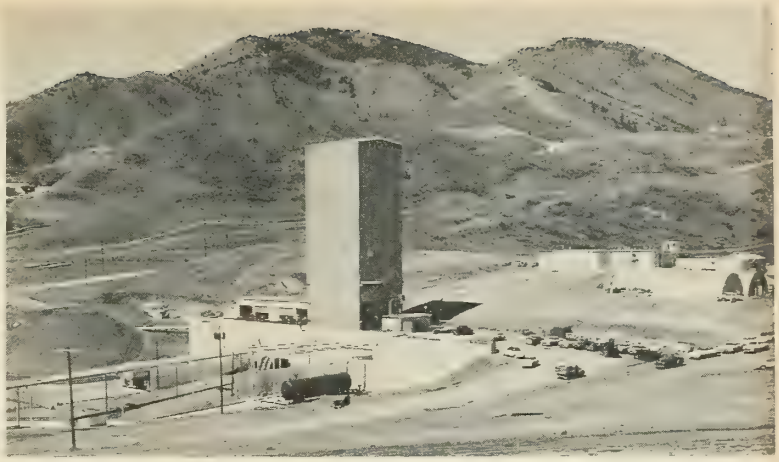
The initial USAF *Titan* development contract, totaling $358 million, has reshaped the geographic organization of the Martin Co. The *Titan* program, centered in the new $10-million facility here, is already in its manufacturing stage.

As a result, a $2-million plant expansion is in the mill. Present employment of 2,500 is expected to reach 5,000 next year. Company officials say building of a landing strip is planned to expedite delivery of parts and for transporting military and civilian people to the site.

The *Titan* program now is broken down into eight departmentalized functions which perform specialized responsibilities in successfully completing the project. Several of these are well underway.

The propulsion section, which has the responsibility for the engine installation, its propellant feed system and its satisfactory marriage to the airframe, is working closely with Aerojet, planning first engine tests at the Denver site.

The airframe section has the responsibility for the design of the structure, the orientation of the various systems within the structure and the general configuration of the missile. This work is in the mill.



Martin's Titan intercontinental ballistic missile effort is in a far more advanced stage than was expected a year ago. Some design conceptions from the Atlas have been incorporated.

The guidance and control section has the responsibility for the analysis, design, development and installation of all of the control equipment which will help the vehicle maintain a stable flight attitude at all times and the integration for guidance within the entire system. Little is known of guidance progress, but it must be assumed that it is as advanced as the *Atlas* guidance.

The ground support and equipment section, which has the responsibility of supplying all the necessary equipment required to launch the vehicle, is well ahead in its overall planning. In all, the *Titan* program is well advanced, and, needless to say, Air Force officials are pleased with the progress.

SPECIFIC DATA:

MANUFACTURER: Martin Co.
MISSION: surface-to-surface ICBM
RANGE: 5,500 mi.
SPEED: Mach 15
WEIGHT: 200,000 lbs. plus
HEIGHT: (est) 100 ft. plus
GUIDANCE. ARMA inertial
POWERPLANT: 1st stage-Aerojet LPR (300,000 lbs.)
2nd stage—Reaction Motors LPR (60,000 lbs.)
GROUND CONTROL: radio ground guidance by Bell Telephone Labs
PROPULSION:
Booster: 300,000 lbs. thrust Aerojet LP motor
Sustainer: 60,000 lbs. thrust Aerojet LP motor
STATUS: component development; $358m in January for continued development
REMARKS:
ICBM, Nose cone-AVCO
warhead-Sandia Corp.



Martin expects to employ 5,000 people at its Denver facility by the end of the year. Most construction work has been completed.



Aerojet's giant-size engines for Titan have been successfully developed and will be at the Denver site for test shortly.

MISCELLANEOUS MISSILES

DING-DONG MB-1 (Bird Dog High-Card)

The *Ding-Dong* MB-1 was the first air-to-air missile to have an atomic warhead. Developed for the Air Force by Douglas Aircraft Co. it was reportedly flight tested with an atomic nose during the May 1957 AEC atomic firings. Liquid and solid propellant versions are under development although the liquid propellant model was the first conceived. Atomic warheads for air-to-air missiles were tested in the spring of 1955 to provide basic information on the missile requirements. Design for the *Ding-Dong* was initiated in 1956.

SPECIFIC DATA:
MANUFACTURER: Douglas
MISSION: air-to-air
GUIDANCE: Hughes
POWERPLANT: NAA LPR (latest version has SPR)
STATUS: reactivation of an earlier Douglas project; in late development or early production
REMARKS: air-to-air interceptor missile, atomic warhead; TINGALING is ballistic spotting version.

GREEN QUAIL

Green Quail is an air-to-surface diversion missile understood to be a member of the *Corvus* family. Missile is believed in late stage of development with first flights expected in early 1958.

SPECIFIC DATA:
MANUFACTURER: McDonnell Aircraft
MISSION: air-to-surface diversionary
GUIDANCE: Sommers Gyroscope
STATUS: late development

DUCK

An air-to-air missile in the research and development stage designed as armament for our long-range and supersonic bombers. The role of this missile as a BDM weapon has not been confirmed at this time. Fairchild is reported as the prime contractor for this Air Force missile.

GOOSE

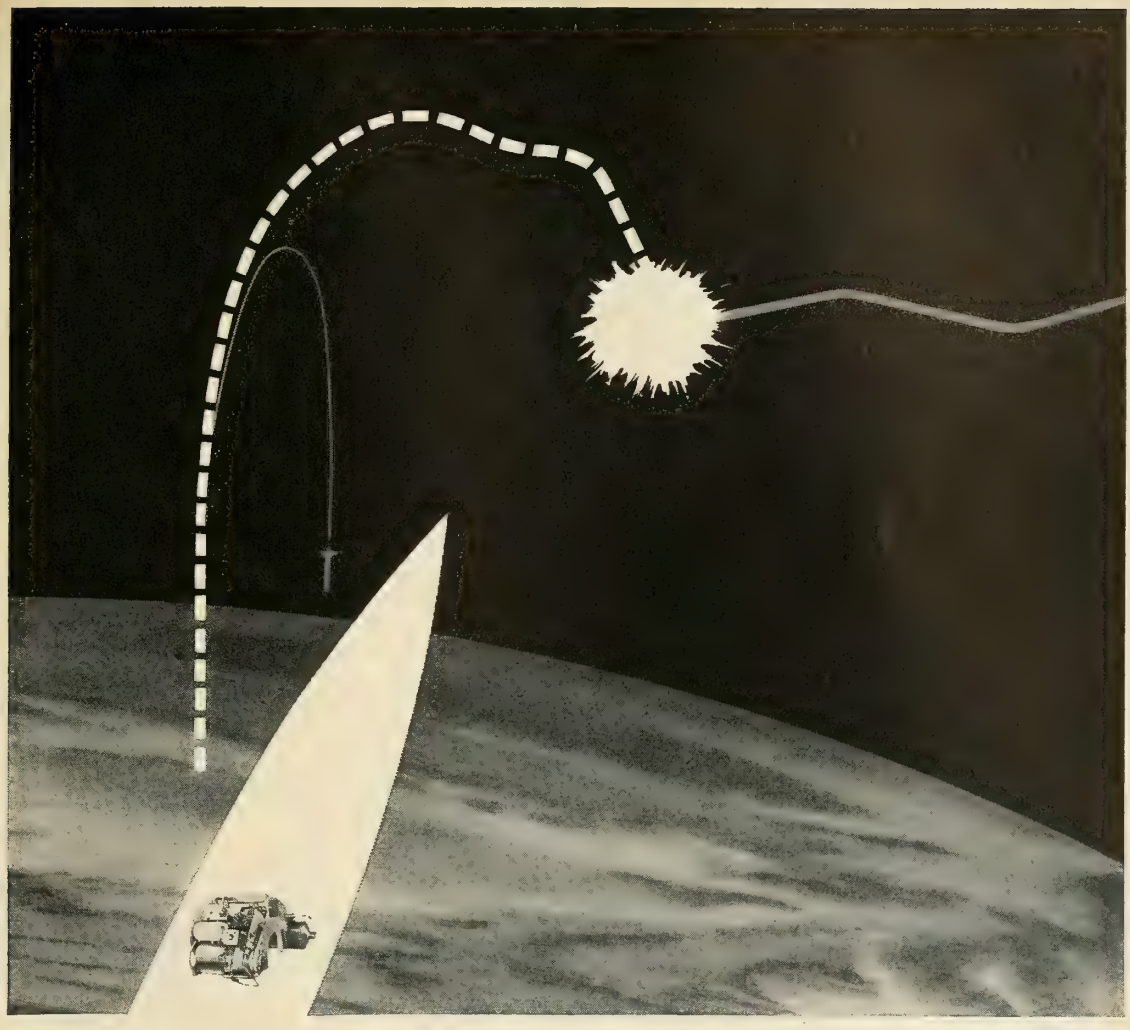
An air-to-air bird in the development and production stage manufactured by Fairchild as a diversionary drone. Launched from a bomber, the *Goose* was designed to decoy intercepting planes or missiles from bomber strike force, i.e., B-52 or B-58 atomic carriers. This turbo-jet aerodynamic cruise missile will probably be operated similarly to the *Rascal* air-to-surface missile. The B-58 *Hustler* has been mentioned as the carrier for the *Goose* and *Duck*.

SPECIFIC DATA:
MANUFACTURER: Fairchild Aircraft
MISSION: air-to-air diversionary
LENGTH: 20 ft. (est)
VELOCITY: Mach 1.25
SPAN: 13 ft. (est)
GUIDANCE: Fairchild radio command
POWERPLANT: Fairchild J-83 or GE J-85
ALTITUDE: 100,000 ft.
LAUNCHER: mother plane
FLIGHT CONTROL: Kollsman
STATUS: production

WS-126A WS-132A

The WS-126A is reported to be under the systems engineering management of Cornell Aeronautical Labs, DE Johnson City. Bell Telephone, Hughes and Raytheon have been engaged in the design and development of a bomber defense missile (WS-126A) for the B-52. Recent indications, however, are that the project has been de-emphasized although it remains a critical AF requirement. It is anticipated that the project will be kept alive.

The WS-132A was to have been the bomber defense missile for the WS-110A. Two development teams (GE/-McDonnell and Republic/Westinghouse) were working on this missile until work was suspended by an AF stop order issued in November 1956. Arma is believed to be still working on a competitive system.



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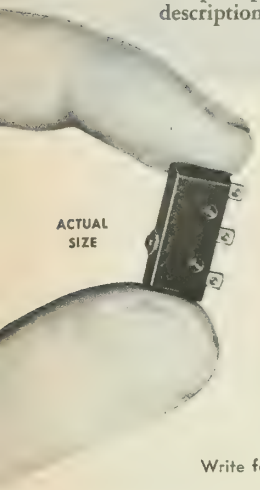
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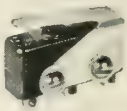
Write for Data Sheet EY-7


Push Button Actuator

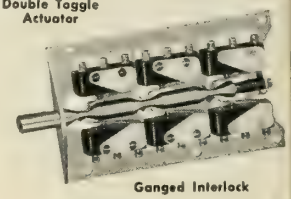

Toggle Actuator (Momentary or Constant Contact)


Double Toggle Actuator

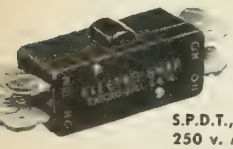

Roller Leaf Actuator


Leaf Actuator


Extension Leaf Actuator

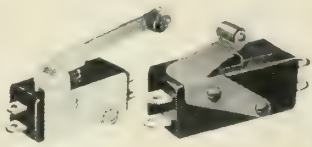

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Write for Data Sheet STY-7


Roller Lever Actuator

Roller Actuator



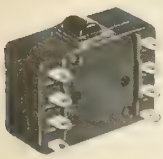

Push Button Actuators (Various button sizes available)




Toggle Actuator (momentary or constant contact)


Extension Leaf Actuator


Special Push Actuator design fire control s

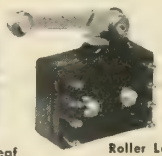


DOUBLE-POLE SIMULTANEOUS ACTION TYPE D-8

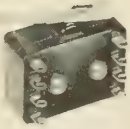
D.P.D.T., 4 Circuit
15 amps, 125/250 v. AC.
10 amps, 30 v. DC Ind.
Eight terminals and four separate circuits which operate simultaneously permite switch to reverse 3-phase motors, replace expensive relays, etc.

Write for Data Sheet DY-7


Roller Leaf Actuator


Roller Lever Actuator


Leaf Actuator


Extension Leaf Actuator




Push Button Actuators (Various button sizes available)

HERMETICALLY-SEALED DOUBLE-POLE SWITCH

Write for Data Sheet HJY-7


Type J2-4


Toggle Actuator for J2-4

D.P.D.T., 4 circuit 10 amps, 125/250 v. AC/30 v. DC.

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Space Medicine

by Hubertus Strughold, MD., PhD.

An important research area in space medicine is the study of the toxicity of rocket propellants—fuels as well as oxidizers. This is a kind of preventive medicine. Basically, the injuries may be caused by chemical reactions with body tissue or by thermal burns, such as those caused by liquified propellants at very low temperatures.

The areas of attack are usually the skin, the eyes, the respiratory tract, and the digestive tract. Protective measures must be taken—special clothing, face shields, etc. The problem of propellant toxicity concerns both crew and ground personnel, and pertinent instructions are important for both.

Ozone is used as an oxidizer in rocket propulsion and is also found in higher concentrations in the atmosphere between 60,000 and 140,000 feet (the ozonosphere). Recently ozone has attracted special medical interest. Dr. H. G. Clamann of the School of Aviation Medicine at Randolph AFB, Tex., in cooperation with Armour Research of Chicago, has carried out experiments in an ozone chamber to determine human tolerance to the gas.

The high altitude balloon flight of Capt. J. W. Kittinger on 3 June was a test in the balloon program of Maj. David G. Simons of the Aeromedical Field Laboratory at Holloman AFB, N. M. From the standpoint of human physiology the altitude reached by Kittinger—96,000 feet—can be considered equivalent to the vacuum of space.

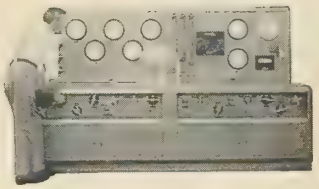
The true nature of the so-called boiling of body fluids above 63,000 feet has been discussed in a paper by Capt. Julian E. Ward, Jr., (J. Av. Med., Vol. 27, pp. 429-439, Oct. 1956). This low-pressure, low-temperature vaporization is a physical process, and does not include chemical reactions in the tissues as in the boiling of food during which protein coagulates. For this reason, the author suggests that a new term "ebullism" (derived from *ebullare:* to form bubbles) should be applied to the phenomenon. The term "boiling" is misleading and should be discouraged, especially in the press. The boiling of body fluids at altitude is actually an unhindered, profuse vaporization.

At the annual meeting of the Aeromedical Association in Denver May 6 to 8, Dr. Alberto Hurtado gave the Louis H. Bauer Lecture on "Natural Acclimatization to High Altitudes." Dr. Hurtado is Research Director of the Institute of Andean Biology at Lima, Peru. It is the only place where acclimatization studies are continuously carried out at altitudes as high as 15,000 feet. The subjects are natives and visiting researchers.

At the same meeting, Prof. R. Margaria, Director of the Physiological Institute at the University of Milan, Italy, reported on experiments in which he immersed fish in water, placed them on a centrifuge, and subjected them to 1500 g for periods up to 10 minutes. They survived for more than twenty-four hours after this extremely high gravitational stress. Frogs survived after exposure on the centrifuge to several hundred g while they were immersed in water.

On July 19 a symposium on Astronautics, organized jointly by the Royal Aeronautical Society, the British Interplanetary Society and the College of Aeronautics, will be held at Cranfield, England. Papers of interest in the field of Space Medicine will be given by Lt. Col. James P. Henry, Chief of the Biosciences Division, ARDC titled "Psychophysiological Hazards of Satellite Flight," and by H. G. Clamann, School of Aviation Medicine, on "Medical Problems in Bio-astronautics."

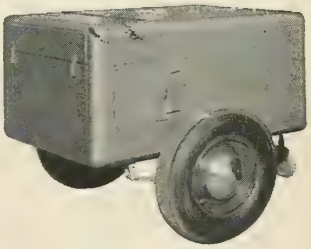
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Missile Miscellany

Six months ago this page started out with a stated main purpose to make people think. Perhaps the clause should have been added: ". . . even if it has to make them mad to do it." Sometimes it's the only way.

With this semiversary note, this page hears: That AF has made at least two efforts to provide sufficient financial incentive to induce private companies to buy away Wernher von Braun Army missile team; that AF recently attempted to cut off Jupiter without a cent of fiscal 1958 R&D money but was foiled by Defense Secretary Wilson; also that AF, rather than famed missile-maker Douglas Aircraft, should take blame for Thor fiasco—for scheduling the impossible and then saying: "Hurry!" With all this, plus interesting timing of Air Force Magazine's "Great Missile Hoax" vis-a-vis Army Jupiter's 1500 mile shot vis-a-vis AF Atlas' 8000 foot misfire, seems like there might be room for another magazine, called Missile Politics, to tell John Q where his missile tax money is really going.

Now to a Russian Admiral admiring Bomarc exhibit on Armed Forces Day who asked: "Can this be used for anti-submarine work?" On the same missile, a query tossed out the other evening: "Why doesn't it have a competitor?" And a quip circulating Washington: "It's going to take a fourth stage engine just to get Vanguard through the red tape!"

But speaking of serious projects, AF's TV-carrying Big Brother satellite may be running ahead of schedule, spurred on by anti-missile missile need to know instant enemy ICBM is fired. Tip-off may be delivery to AF in nine months of a one kilowatt hydrogen-oxygen fuel cell that needs no heat sink; can operate at temperatures from −175 to 350°C at zero gravity with 5-lb./kwh or less weight-to-power ratio and at least 30-day operating life. Proving you never know where missile knowhow's going to pop up next, spheres of Haveg high-temperature material fitted with Diversey-machined molybdenum will measure for the first time ever the molten cores of the world's eleven major active volcanoes at rate of one a year. National Geographic Society's to pay and plans first shot this year in Peru.

Totally unclassified discussion the other morning of problems of getting anti-missile missile high enough soon enough brought this conclusion: Must be solid propellant for instant readiness—these suggestions: by-pass duct a solid propellant motor to add air mass to rocket efflux; core intermediate stage into solid fuel ramjet; afterburn in secondary nozzle behind conventional solid propellant motor (all these designed to put atmosphere to work) —and this forecast: Startling AMM developments within months.

Why doesn't American Rocket Society set up a missile launching base where tomorrow's space-flight engineers, today's amateur missileers can safely static test and fire their hardware? This page bets manpower-hungry missile industry would foot bill if ARS administered. Insurance is no excuse. Lloyd's in London will bet for or against anything.

Now jumping from pad-to-pad—Navy's "second Admiral Rickover" (for missiles, that is), Robert C. Truax, is reportedly on his way back to Washington to head up Polaris Fleet Ballistic Missile program. About time . . . Shades of Swedish sub-seeking seals, U.S. Navy at end of World War II seriously contemplated use of hungry homing pigeons for guiding missiles . . . Credit to a radio disc jockey who quipped: "Nuclear warheads now come in three sizes: small, large and 'where did everybody go?' " . . . This unfortunately apt goal in electronics gear design: To make it idiot-proof . . . Employment at Redstone Arsenal and ABMA's Guided Missile School is highest ever at over 14,400 . . . And a serious report that man may place his finger on the moon by Christmas . . .





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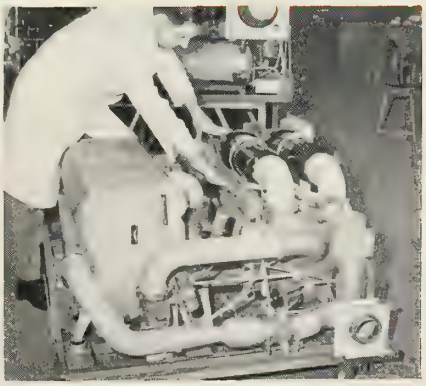
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Stratos' Model GEA120-1 air conditioning system being prepared for production test.

To Probe Tomorrow

Photography by
R. M. LaMar and E. Hull





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reveal new sciences. These colors of tomorrow
shot for m/r in the new Aerosciences Laborator
General Electric Company's Missiles and Ordna
Systems Department at Philadelphia. The m
million dollar facility, to be finished this fall,
an original purpose to study the aerodynamic
materials problems of hypersonic flight. Alre
however, Dr. Leo Steg (above), the lab's e
getic young director, admits that not even he
define the limits of these tools that probe the
known. The dull thud of a shock tube bursting
diaphragm, the devil's spectrum of a plasma je
these are the sounds and colors of escape, Mars
bit, return and reentry, of research in a new



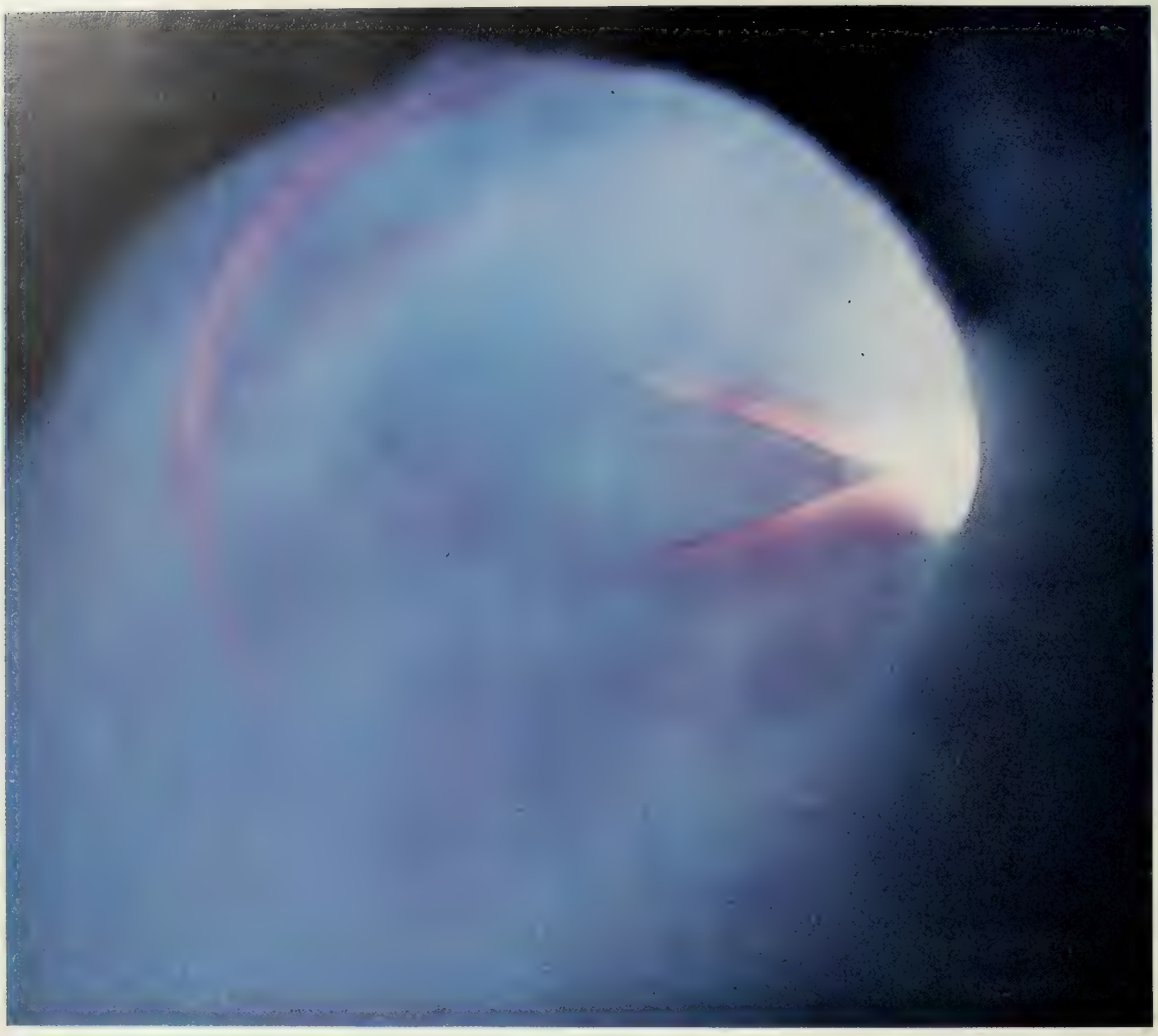
Like a ring-sight zeroing in on the future, the carbon arc-powered solar furnace above can concentrate 2700°C heat in the test area. To the far left, opposite, a compressed asbestos test cone glows, flares and disintegrates under the 12,000°C plasma blast from a water stabilized arc. Moving right, the next two pictures show the same jet with a graphite expansion nozzle in place. AF Office of Scientific Research's Col. Wm. O. Davis says such a stream of ionized particles exhausting through magnetic coils may soon provide basic ion propulsion know-how. Next, a copper sample waits its turn; in an instant glows red; then melts, spalls and vaporizes in tell-tale copper green. This arc, a joint MOSD—Chicago Midway Laboratories development initiated by GE's Dr. B. Levine, uses a half-inch electrode and 200 kw of DC power. Water swirling in the plastic annulus cools the unit, confines the arc and is vaporized and ionized into a plasma. The GE MOSD lab also boasts a liquid nitrogen stabilized arc using a one-half inch electrode and 200 kw. Possible later versions requiring several thousands of kw will offer versitility and a wider range of test conditions—tens of thousands of degrees centigrade and extremely high hypersonic velocities.







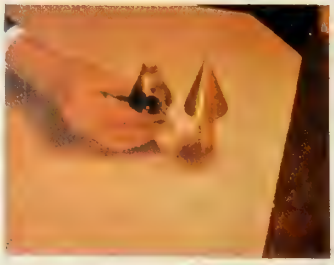




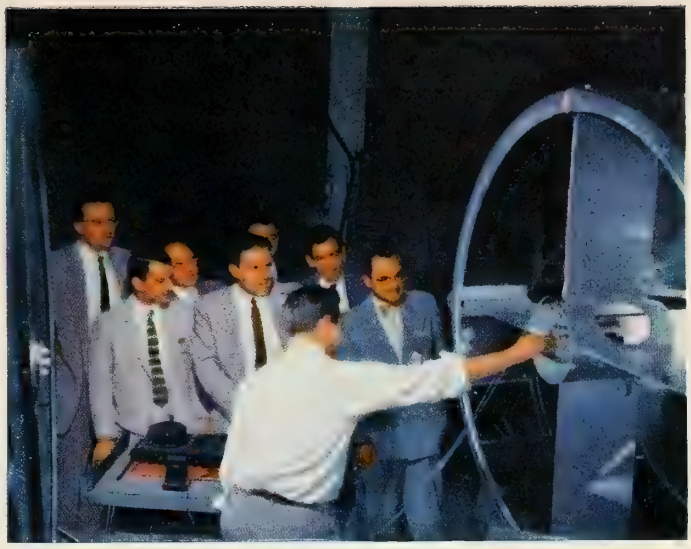




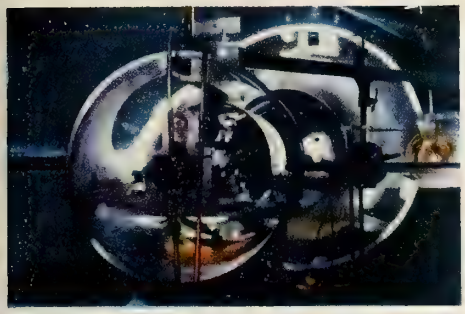


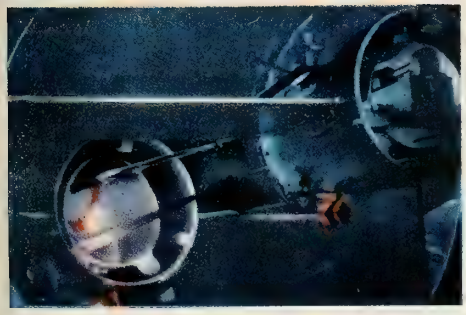


Not man's first assault on Saturn's ammonia atmosphere, but the moment of ignition of GE MOSD's liquid nitrogen "steam" as it pours from the test chamber. Even though liquid nitrogen's temperature is —195°C, the unit promises temperatures up to 12,000°C and more closely simulated atmospheric conditions. These arcs provide heat transfer rates on the order of 500 BTU per square foot per second. The surface temperature of the sun is approximately 6500°. In charge of developing this unit are Drs. John McGinn and Harold Wachman (white shirt). Note the heavy frost on the lead lines and swirl chamber. This equipment can provide test conditions for seconds or minutes, depending only on the length of the electrode. Note also, in the before-and-after shot, the beating a brass nose cone took from heat and blast in just a few seconds.

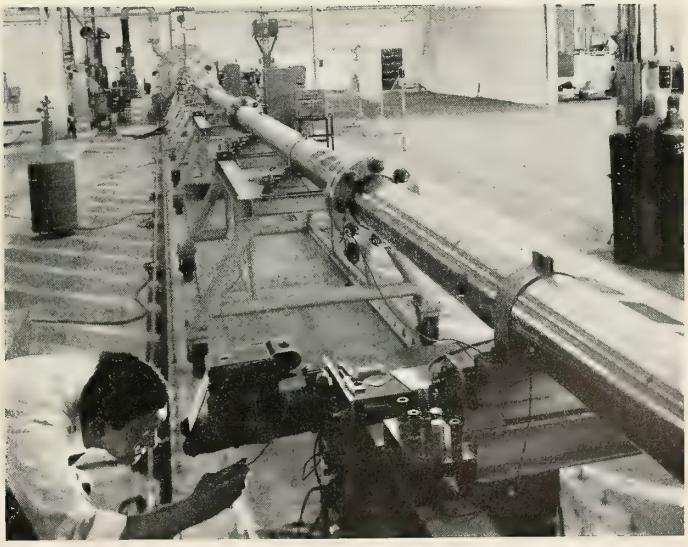


Mr. Jesse Metzger, MOSD's solar furnace researcher, sweats it out between heat source and target to explain a new technique to Aeroscience's associates (left to right): Dr. Wallace Warren, Dr. Wm. C. King, Jr., Mr. James Reid, Dr. Leo Steg, Dr. Harold Wachman, Dr. Joseph Farber and Mr. Clifford Mannal. Actually, the name Aeroscience will probably be discovered to be a misnomer. The potentials of some of these tools has been described as "fantastic." It seems certain that their contribution to man's knowledge of the basic state of his universal environment will far exceed the current confining limits of this definition.









A bit hot for marshmellows, solar furnace has melted its way through a one-eighth inch thick sheet of stainless steel (top). Again looking into the white-hot heart of this inexpensive laboratory tool, a lucite test sample melts from its probe in a few seconds. And to the right center, an epoxy resin slug glows red hot in scientist's tongs. Slug has been removed before destruction in order to evaluate rate of deterioration and changes in material's chemical and physical properties under high heating. To the right, MOSD's most expensive Aeroscience research tool now in place is this six-inch diameter shock tunnel. Still building up to full power, it has already produced Mach 10 shock waves. A unique feature of this installation is the expansion throat at the far end, permitting study of large-scale models. Contemplated for addition to the array is an electric arc discharge accelerator, theoretically capable of model velocities in the hyper-hypersonic range—beyond the realm of known requirements.



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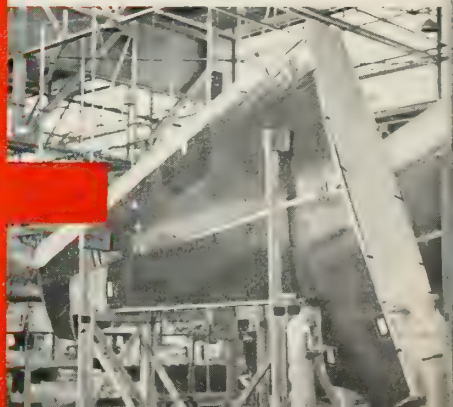
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NEW MISSILE PRODUCTS

MISSILE TRACKING SYSTEM



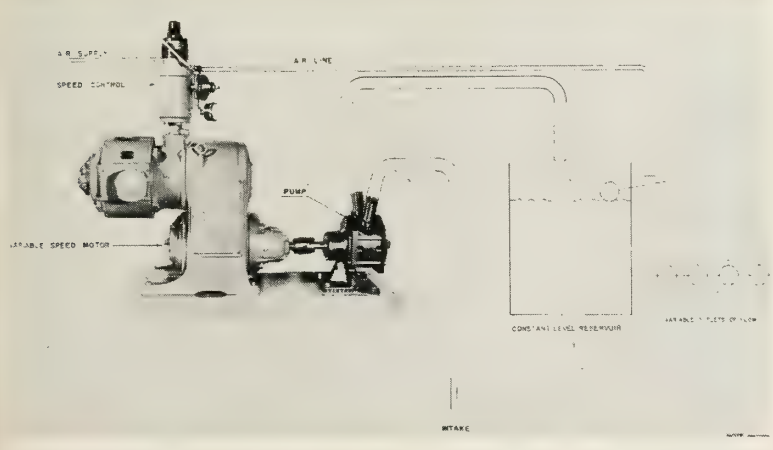
First completely mobile optical tracking system, capable of photographing an object 2″ x 7″ at an altitude of 4 miles, has been delivered to the Air Research & Development Command. System will soon undergo range evaluation tests at ARDC's Armament Center, Eglin AFB, Fla.

Called Telescopic Photographic Recorder (TPR), the 6-ton system will be used to photograph the flight history of missiles, aircraft and bombs. It will record documentary information such as altitude, spin rates and correlated time data. TPR was designed and built by the Perkin-Elmer Corp.

TPR can be readily moved to any desirable site and can be operated either remotely or by operators. It consists of a 9′ long, 100″ focal length reflecting telescope equipped with 70 mm motion picture camera, two sighting scopes, controls, electronic and hydraulic equipment. Primary telescope is a 3-in-1 system.

Circle No. 207 on Subscriber Service Card.

PUMP-MOTOR SET



Variable flow rate pump-motor set designed specifically for pilot plant, laboratory or process work where controlled and varying rates of flow of corrosive fluids and abrasive slurries are required is being marketed by Vanton Pump & Equipment Corp.

The pump is driven by a variable speed source so that a relatively linear relationship between speed and output can be obtained. This offers a practical and exact way of varying the rate of flow.

The sensing and controlling portion of the system is an air signal operating at an instrument pressure of 3 psi to 15 psi. The signal pressure controls the power air through an amplifier, thus controlling the rpm of the pump drive.

Pump has no stuffing boxes or shaft seals and the fluid conveyed is isolated to contact only materials used in the flexi-liner and body block.

Circle No. 265 on Subscriber Service Card.

FLAME-RETARDANT LAMINATE

A new flame-retardant glass epoxy laminate, featuring excellent flame and heat resistant properties, has been developed by Continental-Diamond Fibre Corp. When removed from flame laminate will not continue to burn because of self-extinguishing characteristics.

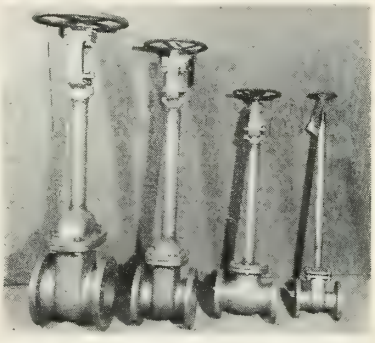
Laminate can be used continuously at temperatures up to 300°F. Above this mark it can be used intermittently. Available in plain form for power applications and metal-clad form for printed circuitry. Can be obtained in sheets ranging from .010″ to 1″ in thickness.

Circle No. 200 on Subscriber Service Card.

STAINLESS STEEL VALVES

Cooper Alloy Corp. has developed a line of stainless steel gate and globe valves for handling liquid oxygen and other extremely low temperature liquids.

Valves which operate at around —300°F and pressures of 150 psi to



600 psi are designed with extended bonnets to permit the use of heavy insulation between the operating mechanism and the pipe line. This serves to prevent heat pick-up into the valve and its contents and to allow free movement of the operating mechanism.

Furnished with Teflon chevron packing, valves are available in both gate and globe designs from ½″ to 12″.

Circle No. 218 on Subscriber Service Card.

NUCLEAR ELECTRIC TIMERS

A small, lightweight electric timer suitable for use in time delays, missile destructors, pilot ejection systems, alarm systems, and warheads uses a nuclear battery as its power source.

Called Betachron, the unit was developed by the Moos Division of Universal Winding Co., Inc. The timer has a shelf and use life of over 25 yrs. and is capable of operating reliably over wide ranges of temperatures, acceleration and vibration. Suitable for use in missile systems where time delays from microseconds to 40 hrs. are required with an accuracy of ±3%.

Timer is capable of delivering energy pulses up to 250,000 ergs, is supplied and encapsulated in a metal case with standard connectors at the output. Heart of timer is nuclear battery which converts nuclear energy directly into electrical energy.

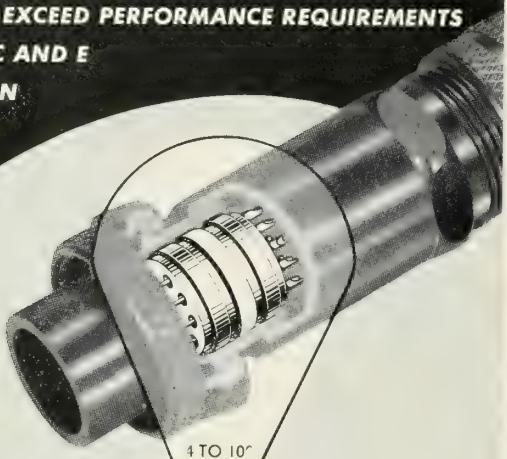
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Announcing...

PYLE-NATIONAL'S NEW CONNECTORS

for MILITARY-INDUSTRY

THAT MEET AND EXCEED PERFORMANCE REQUIREMENTS OF CLASS A, B, C AND E OF SPECIFICATION MIL-C 5015B



ask for

PYLE-STAR-LINE connectors

Plugs and Receptacles
ENVIRONMENTAL
NEPTUNE SERIES
Bulletin #637



featuring the SILICONE INSULATION SANDWICH

THE PYLE-NATIONAL COMPANY

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District Offices and Representatives in Principal Cities of the United States
CONDUIT FITTINGS • CIRCUIT CONTROLS • LIGHTING EQUIPMENT

SINCE 1897

Circle No. 37 on Subscriber Service Card.

CONSTANT DAMPING GYRO

A new rate gyro, Type JRT, has been developed by the Boston Division of Minneapolis-Honeywell. Instrument measures absolute rates of rotation in inertial space. Damping is electro-mechanically controlled to maintain a constant damping ratio over the entire operating temperature range of —65°F to 175°F.

The rate gyro is designed specifically for flight control of long-range missiles and for instrumentation in missiles and aircraft where ambient temperatures are not controlled and at the same time where



low threshold, minimum hysteresis, excellent linearity, high natural frequency and ruggedness are essential.

Features include: excellent linearity, 25% of full scale; low hysteresis, less than .1% of full scale; low threshold, less than .01°/sec; microsyn pickoff, variable reluctance type providing infinite resolution and high signal-to-noise ratio; full scale rate, up to 1,000°/sec; full scale output, up to 12v; withstands 100g shock, 15g to 2,000 cps vibrations; size 2 7/64" diameter, 4 5/16" long; weighs 2 lbs.

Circle No. 209 on Subscriber Service Card.

COUNT RATE METER

A logarithmic count rate meter build to the latest ORNL specification Q-1454-B is being produced by the Victoreen Instrument Co.

Based on the Cooke-Yarborough circuit, Model 727 is a wide-range instrument for use with all types of radiation



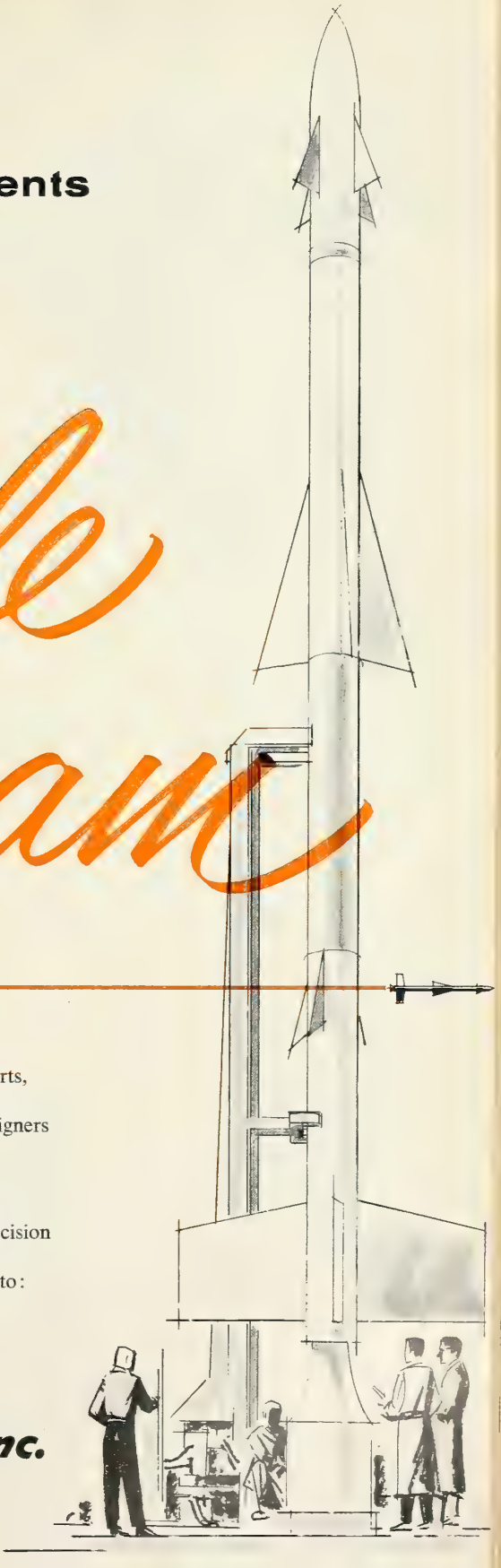
detectors. Applications include gamma monitoring with scintillation counter, beta-gamma monitoring with Geiger counter, and gamma ray spectrometry.

Meter eliminates need for manual or electrical switching as is required in linear-type rate meters. Range is from 10

Leader in Jet Components

can help speed your

Missile Program



Experience gained in producing over 100,000,000 forged parts, stainless steel weldments, and assemblies for all jet engine manufacturers is available now to designers and manufacturers of missiles.

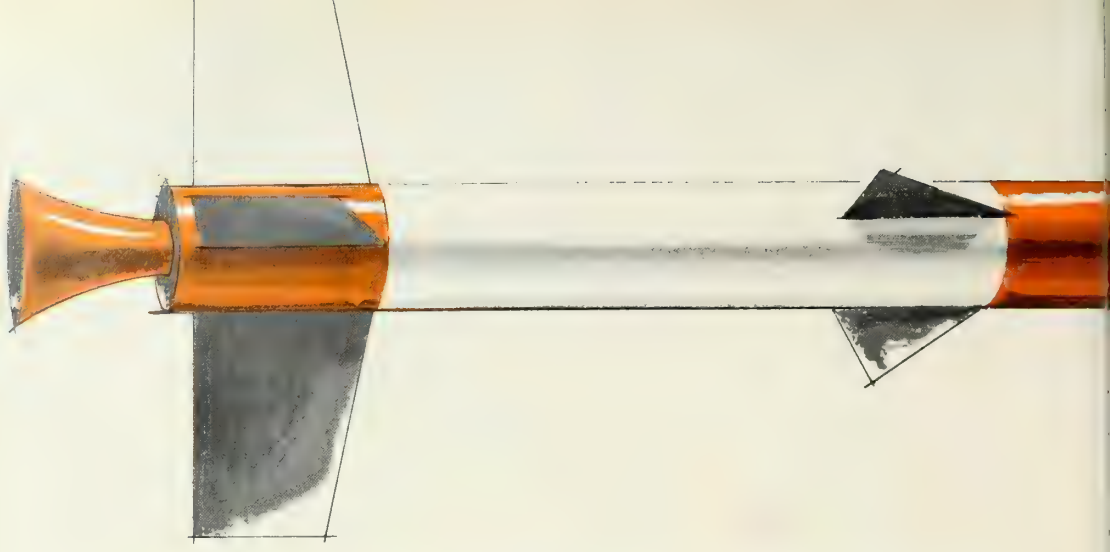
Let us discuss your projects and your needs with you now. Your missile can then have the benefit of what the Jet Division has developed for the jet-engine industry . . . precision forgings, high-temperature alloys, resistance-welded stainless steel assemblies. Write or phone today to:

MISSILE PROJECTS DEPARTMENT

JET DIVISION

Thompson Products, Inc.

CLEVELAND 17, OHIO



for your missile program...

complete engineering and test facilities to augment your manpower

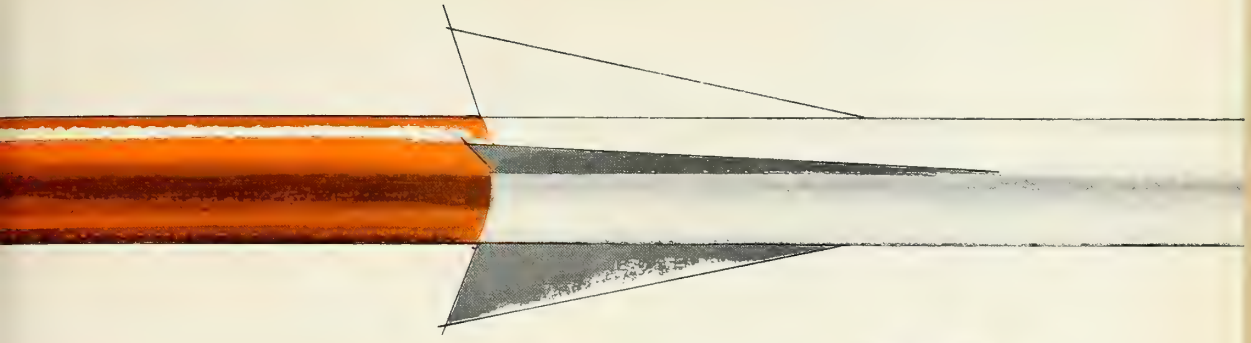
The men at the Jet Division who helped develop forgings and stainless steel weldments for jet engines are ready now to work with missile engineers on projects using their experience and talents.

You can use their services in the development of air-frames, tanks, and other structural components of missiles. You can also use their experience with metals at high temperatures in the design of your missile power-plants and skin-surface components.

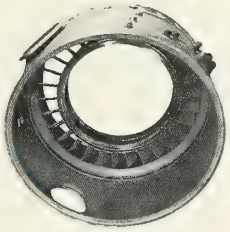
A Jet Division engineer will be glad to call at your convenience to discuss your projects, timetables, and requirements.



Tensile tests at elevated temperatures are run on various alloys in Jet Division labs to determine their strengths under missile equivalent operating conditions.



for your missile program...



weldments in stainless and high-alloy steel and titanium made to your specifications

High-precision weldments that combine careful forming, all types of welding, and accurate placement of bosses and holes, can be designed and produced for your missile at the Jet Division.

Our experience in the production of titanium, high-alloy and stainless steel components for jet engines can give you a head start on your missile projects. Special Jet Division techniques of welding and stress-relieving provide maximum strength at minimum weight in metals that can resist the operating temperatures and stresses of missiles.

Let us discuss your weldment and machining requirements and show you how Jet Division engineering and production can quickly augment your own facilities.



MISSILE PROJECTS DEPARTMENT

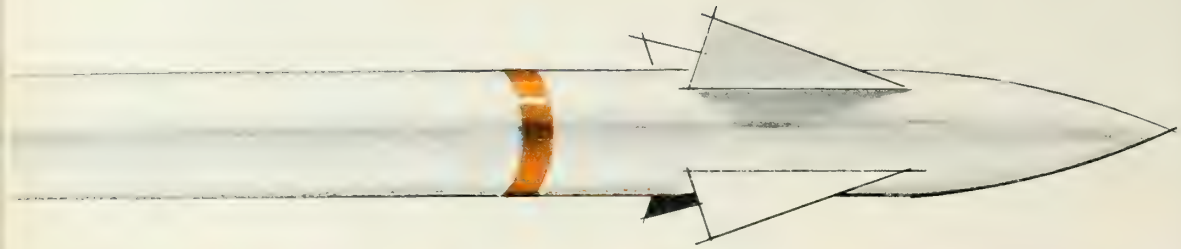
JET DIVISION

Thompson Products, Inc.

CLEVELAND 17, OHIO

Special welding procedures and jigs are used in welding service-stressed stainless and alloy steel components into a finished structure at the Jet Division.





for your missile program...

Forgings made to closest tolerances for high-temperature service

Starting in 1944, the Jet Division was the first manufacturer of high-precision forgings for jet aircraft engines.

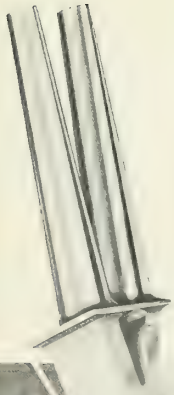
More forged parts of titanium, stainless and high-alloy steels for engines of every manufacturer have been made by the Jet Division than by any other producer.

Every jet engine manufacturer uses Jet Division forged parts.

Forged to extremely close tolerances and contours, precision parts produced by the Jet Division often require no costly machining before assembly. Their use in your missile can speed delivery, reduce finishing time, eliminate capital plant investment.

Complete machining and test facilities are also available for your missile subcontract work.

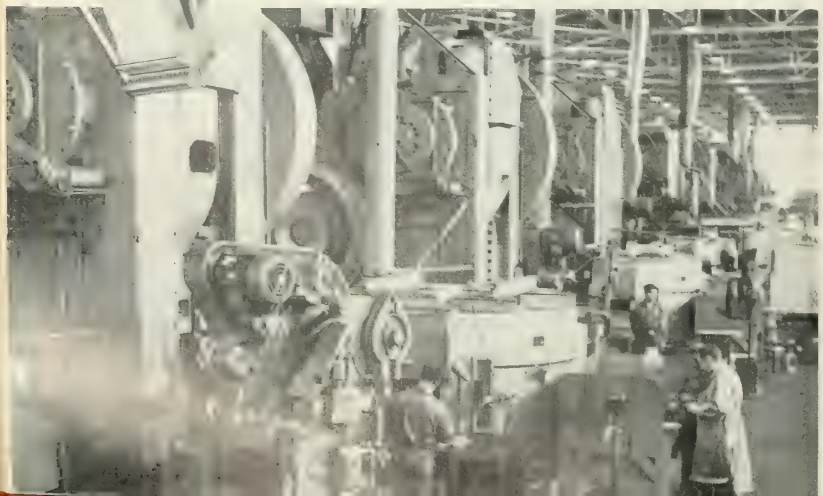
Our sales engineers will gladly discuss your missile project requirements at your convenience.



WRITE FOR FREE BOOKLET

The complete engineering and manufacturing facilities of the Jet Division are described in Booklet MI-57. Write on your company letterhead for a copy.





MISSILE PROJECTS DEPARTMEN

JET DIVISION

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CLEVELAND 17, OHIO

Battery of forging presses up to 4000-ton capaci produces precision parts in titanium, stainless, a alloy steels at the Jet Division's press-forging sho

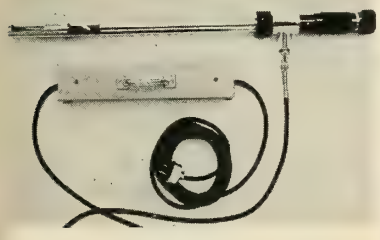
to 1 million counts per minute in 5 decades on a single scale. Accuracy is within ±2% over the entire decade and is better than ±1% in the vicinity of the calibration point. Drift is less than 1% in 24 hours.

Meter operates on 150 vac, 60 cycles, draws 135 watts. Relay pack panel is 8¾" x 19", weighs 60 lbs.

Circle No. 206 on Subscriber Service Card.

MIRROR BORESCOPE

Borescope developed by Lenox Instrument Co. permits complete internal inspection of tanks, vessels, combustion chambers and other equipment by means of an adjustable mirror which can be controlled by a hand-wheel to permit scanning from restrospective through right



angle to forward oblique.

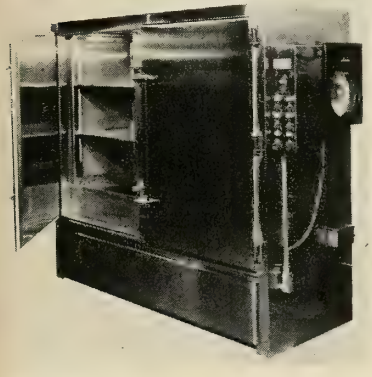
Large field of view offered by instrument makes it easier to detect flaws, pits, cracks or deterioration to assure perfection in manufacturing and maintenance. Borescope gives magnification of 10 power, a field of vision of 9" in diameter at a distance of 24", and has a viewing head with 13/16" diameter 100 watt lamp.

Circle No. 212 on Subscriber Service Card.

ENVIRONMENTAL EQUIPMENT

Labline, Inc. is producing a line of Environ-Cabs to simulate temperature and humidity conditions over a range of 20% to 95% relative humidity and temperatures from 40°F to 200°F, in four sizes—10, 20, 30 and 40 cu. ft.

Environ-Cabs are suitable for laboratories and plants where such tests must be run. Features are double-wall cabinets with interiors and exteriors of 1808 stain-



less steel, insulated with Fiberglas, perforated diffuser walls for uniform air flow, dual blowers, dual hydraulic thermostats for temperature control, silicone door gaskets, adjustable shelves.

Humidity pan with heaters and automatic water level supplies the necessary humidity conditioners. Where required,

IERC's FREE TUBE SHIELD GUIDE helps you improve electron tube reliability—



—provides information you need to properly match over 1,400 sizes and types of electron tubes and heat-dissipating tube shields for best cooling, retention and protection against shock and vibration!

New 20 page IERC Heat-dissipating Tube Shield Guide has been carefully and accurately compiled in answer to many hundreds of Electronic Engineer suggestions and requests for just such a practical Guide. New design applications and retrofitting of electronic equipments with IERC Heat-dissipating Tube Shields (for the excellent cooling, extended tube life and reliability they provide) created the need for this type of professional information – plus another "first" for IERC – *the first reference manual of this type* to the electronic industry!

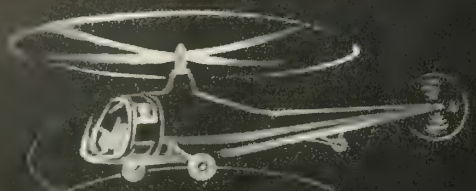
For a free copy, please send request on your company letterhead to: Dept. TSG.

International
electronic research corporation
145 West Magnolia Boulevard, Burbank, California

Heat-dissipating tube shields for miniature, subminiature, octal/power electron tubes

Circle No. 38 on Subscriber Service Card.

...thermal sensing unit



C·P·I PLUGSTAT®

—wherever temperature limit indication is required



CPI PLUGSTATS provide precise thermal warning without calibration drift. Small physical size has been combined with rugged construction. Special alloy contacts assure clean make-and-break. Capable of 200°F overshoot from high or low normal setting. Available also with AN connector. Rated at ¼ ampere, 28 volts, AC or DC resistive loads. Contacts NO or NC. Weight approx. 1.5 oz.

Proven dependable in —
AIRCRAFT GENERATORS
AIR COOLED ENGINES
WATER COOLED ENGINES
TRUCK REAR ENDS
MARINE ENGINES
BEARINGS
PIPED LIQUIDS
GEAR BOXES

CONTROL PRODUCTS INC

306A SUSSEX STREET
HARRISON, NEW JERSEY

Circle No. 39 on Subscriber Service Card.

automatic temperature recorders, controllers and programmers may be installed. Thermopane observation windows, terminal boards for elecrtical testing, penetrations for pipes, wires, etc., are optional.

Circle No. 204 on Subscriber Service Card.

MINIATURE SWITCHES

Airtron, Inc. has developed a miniature waveguide switch for applications requiring minimum size and weight. Switch provides rapid switching of signals from any one of three positions to either of the remaining two and will not change to another position upon failure of power supply.

Electrical characteristics of the 1" x .5"-size unit includes a frequency range of 8,500 to 9,600 mc/sec with a maximum VSWR of 1.10 and minimum isola-



tion of 40 db. Maximum switching time is .25 sec. for 240° operation and .15 sec. for 120° operation. The universal switch operates at 3 amperes maximum at 28 vdc nominal and employs R.F. and pressurized fittings built into the switch, giving up to 20 lbs. of pressurization throughout.

Available in Xs and X_L band series, switches are of rotary channel type using a circular bend in the rotor and a broadband internal choke design.

Circle No. 210 on Subscriber Service Card.

MAGNETIC COUNTER

Abrahms Instrument Corp. is marketing improved models of their 3- and 4-digit magnetic counters for use in aircraft and missile applications.

Available in additive or subtractive types with manual reset wheels, the counters record pulses accurately up to 1,200



counts per minute. Actuated electromagnetically, counters can be connected in vacuum tube plate circuits or operated by any contacting device.

A variety of mounting methods is possible and units can be supplied with

or without panel mount cases.

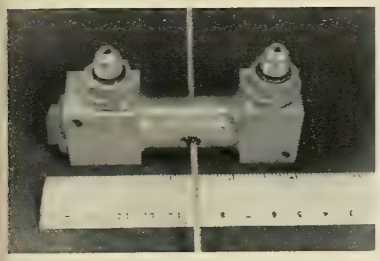
Snap-door on front of case allows convenient resetting. Counters available for all common voltages from 6 to 110 vdc. Three-figure counter measures ⅞" x ⅞" x 2", weighs 2 oz.

Circle No. 216 on Subscriber Service Card.

CABLE CUTTER

A ballistically-operated cable cutter with self-contained cartridges has been developed by Stanley Aviation Corp. Triggered by low incoming gas pressure, the unit contains two independently fired cartridges, either of which produces sufficient force to sever a ⅛" steel cable.

Weight is .45 lbs., unit measures, 4" x 1" x 2¼". Device is applicable to



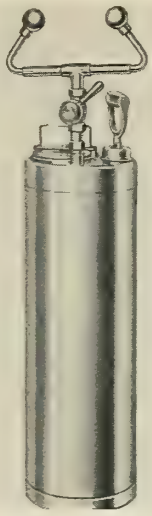
any system requiring instantaneous, reliable cutting of cables, wires, tubes or rods.

Other models are designed to operate from mechanical or electrical signals, rather than pressure input, and provide for variation in mounting position, cable orientation and changes in angular relation of input connections.

Circle No. 219 on Subscriber Service Card.

EYE-WASH FOUNTAIN

A portable emergency eye-wash fountain, for instant eye first aid where normal water supplies are not available, is being manufactured by Haws Drinking Faucet Co.



Model 8950 is designed for use by crews working in remote areas. The corrosion-proof stainless steel tank has a carrying strap and holds three gallons of water instantly avialable to flood the eyes and wash away dangerous substances or particles. Specially designed fountain heads project water into the eyes with a soft, flushing stream.

Pressure is build up within the tank by means of the large pump handle. Pressure maintained for an 8-hr. period. Weight is about 40 lbs. loaded, 15 lbs. empty.

Circle No. 217 on Subscriber Service Card.

PROGRAMMER COUNTER

Precision-made devise turns on and off test apparatus whose limits are sensed by strain guages, thermocouples or other transducers that have a maximum output not exceeding 100 mvdc. Instrument has been developed by Spar Engineering & Development, Inc.



Unit eliminates need for manual control of test cycling and simplifies setting up of equipment each time test is to be run. The Spar program counter is said to be a stable, precision mv electronic relay having adjustable energizing and release thresholds and DPDT 15 amp contacts. Its two, adjustable, stable thresholds provide for precise selection of

LENOX
DETECTS HIDDEN DEFECTS



For internal visual inspection, LICO BORESCOPES are dependable over the years.

Use a precision made LICO BORESCOPE for accurate inspection of tubes, hollow forgings, cylinders, combustion chambers, blind rivets, etc.

- LICO optical systems give a wide field of view at 3-4 power, or any desired magnification.
- Four self-luminous, interchangeable viewing heads are available:
  - **Circumference:** for rapid panoramic inspection
  - **Prismatic:** for close angular viewing
  - **Forward:** for blind bores
  - **Special:** for various angles of view
- Ultra-violet light can be built in for Magnaflux inspections
- LICO instruments are available in one piece or in sections
- Special designs can be readily fabricated from stock parts

LICO BORESCOPES are widely used throughout industry in sizes from a small quill to 2¾" in diameter and from a few inches to 85 feet in length. Write, wire or call for our bid on an inspection instrument to meet your needs.

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2010 CHANCELLOR STREET
PHILADELPHIA 3, PA.
Phone: RIttenhouse 6-6653

Circle No. 40 on Subscriber Service Card.

NEW *Harmeco* PURAFLO FILTERS

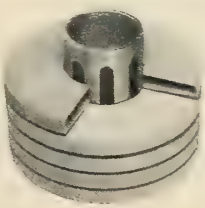
Pneumatic Type for Compressible Gases—Pressures to 6,000 lbs.



Harmeco PURAFLO Filters are available in various case designs to suit any piping requirement for filtering helium, nitrogen and other compressible gases at porosity ratings of 2, 5, 10, 20 or 40 microns or coarser. Interchangeable multi-tube sintered stainless steel wire wound elements or strainers are optional. Case is carbon steel forging; stainless steel, monel or other materials as specified.

ELEMENT MANIFOLD PIPE ASSEMBLY

Double tapered one piece Harmeco hollow sintered bronze disc elements provide deep uniform, dependable filtration. Spacing between the discs is uniform when assemblies are stacked and sealed in ported manifold pipe. One piece element design eliminates slip fits or organic bonding materials. The double tapered, hollow disc design prevents blocking off of surface area due to possible cocking of the elements on the manifold pipe. Result: greater filtering area; uniform porosity control; clean decontaminated products.



For further information write to:

HARMAN EQUIPMENT COMPANY
3605 E. Olympic Blvd., Los Angeles 23, California

HARMAN EQUIPMENT CO. PURAFLO LOS ANGELES, CALIF.

Circle No. 41 on Subscriber Service Card.



BOEING PHOTO

. . . ARE PROTECTED BY THE B&H JETCAL® ANALYZER

Two of the most important factors that affect jet engine life, efficiency, and safe operation are *Exhaust Gas Temperature (EGT)* and *Engine Speed (RPM)*. Excess heat will reduce "bucket" life as much as 50% and low EGT materially reduces efficiency and thrust. Any of such conditions will make operation of the aircraft both costly and dangerous. The *JETCAL Analyzer predetermines* accuracy of the EGT and (interrelatedly) Tachometer systems and isolates errors if they exist.



The *JETCAL* ANALYZES JET ENGINES 10 WAYS:

1) The JETCAL Analyzer *functionally* tests EGT thermocouple circuit of a jet aircraft or pilotless aircraft missile for error *without running the engine or disconnecting any wiring*. GUARANTEED ACCURACY is ±4°C. at engine test temperature.

2) Checks individual thermocouples "on the bench" before placement in parallel harness.

3) Checks thermocouples within the harness for continuity.

4) Checks thermocouples *and* paralleling harness for accuracy.

5) Checks resistance of the Exhaust Gas Temperature system.

6) Checks insulation of the EGT circuit for shorts to ground and for shorts between leads.

7) Checks EGT Indicators (in or out of the aircraft).

8) Checks EGT system with engine removed from aircraft (in production line or overhaul shop).

9) Reads jet engine speed while the engine is running with a guaranteed accuracy of ±0.1% in the range of 0-110% RPM. Additionally, the TAKCAL circuit can be used to trouble shoot and isolate errors in the aircraft tachometer system.

10) JETCAL Analyzer enables engine adjustment to proper relationship between engine temperature and engine RPM for maximum thrust and efficiency during engine run (Tabbing or Micing).

ALSO *functionally* checks aircraft Over-Heat Detectors and Wing Anti-Ice Systems (thermal switch and continuous wire) by using TEMPCAL Probes.. Rapid heat rise . . . 3 minutes to 800°F! Fast cycling time of thermal switches . . . 4 to 5 complete cycles per minute for bench checking in production.

Tests EGT System Accuracy to ±4°C at Test Temperature

(functionally, without running the engine)

Tests RPM Accuracy to 10 RPM in 10,000 RPM (±0.1%)

The JETCAL is in worldwide use . . . by the U. S. Navy and Air Force as well as by major aircraft and engine manufacturers. Write, wire or phone for complete information.

B & H INSTRUMENT CO., INC.

3479 West Vickery Blvd. • Fort Worth 7, Texas

Sales-Engineering Offices:

VALLEY STREAM, N. Y.: 108 S. Franklin, LO 1-9220 • DAYTON, O.: 209 Com mercial Bldg., MI 4563 • COMPTON, CAL.: 105 N. Bradfield St., NE

upper and lower operating limits and a counter, which may be of the reset type, registers each cycle.

Instrument operates on 110 vac.

Circle No. 205 on Subscriber Service Card.

TANTALYTIC CAPACITORS

New "King Size" high temperature tantalytic capacitors for low voltage direct current capacitors with high microfarad values in a small space have been added to General Electric's Capacitor Department line. Three rectangular case sizes with similar base dimensions of 1.316" by 0.75" are being produced.

Heights vary from 1.375" to 2.5" with typical capacities of 1000 mico-

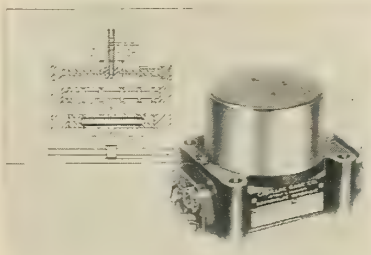


farads at 30 volts to 100 microfarads at 20 volts. The capacitors are rated for 1000 hours operation at 125°C with not more than 20 percent loss from 25°C capacitance after the 1000 hour period.

Circle No. 225 on Subscriber Service Card.

ELECTRO-HYDRAULIC VALVES

A new series of Electro-Hydraulic Servo valves, known as the FC200 series,



has been developed by Cadillac Gage Co. Series is comprised of three models.

Valves represent a marked departure from previous design concepts and are capable of functioning reliably under the rigorous operating and ambient conditions encountered in modern high performance aircraft and missiles. They utilize a closed loop hydraulic control circuit to position the output stage and are of a completely balanced push-pull construction.

No springs are incorporated in the design. The valves have a minimum of moving parts, incorporate a single large capacity filter element to protect the control stage, and are of "dry coil" design.

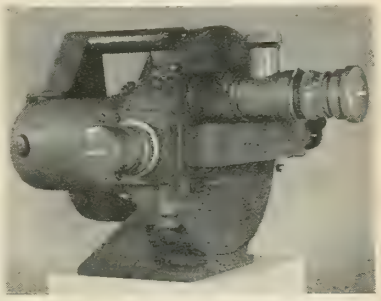
Circle No. 238 on Subscriber Service Card.

HIGH SPEED CAMERA

Fastex high speed motion-picture and oscillographic camera and a 16 mm projector and a motion picture missile camera have been developed by Wollensak Optical Co.

Fastex-WF-17 combination high speed motion picture and oscillographic camera was designed to record both mechanical and electrical data on the same film. It is particularly useful where studies of short duration are required. Camera takes 100' daylight loading spools, has speed ranges from 150 to 8,000 pictures per second, and can be used for either picture or oscilloscopic recording independently.

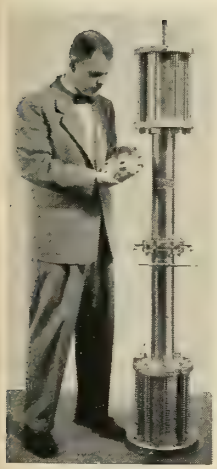
The projector was developed for the study and analysis of subjects filmed by high speed cameras. Films can be pro-



jected without flicker as slowly as 2 frames-per-second. In addition, normal speed of 16 frames-per-second, frame by frame or still picture may be shown.

The Fastair high speed missile camera, in addition to its rugged construction capable of withstanding high g loads,

Now . . . shock test with a controlled 10,000-pound thrust



The HYGE shock tester, manufactured and marketed by CEC under license from the Convair Division of General Dynamics Corporation.

Simulate actual service conditions and test shock resistance of parts and assemblies. Make *repeated* tests accurately.

The new HYGE shock tester will produce specific acceleration and/or deceleration wave forms for desired durations.

In theory, it can produce a build-up rate of 200,000 g's per second from zero to peak acceleration, with a pattern free of high-frequency transients.

HYGE can be used to develop controlled impact shocks from 2,000 to 6,000 g's—accurately.

HYGE is available in standard types, or in a "kit" of modular components. Send for Bulletin P4-70 for details.

Consolidated Electrodynamics

Rochester Division, Rochester 3, N.Y.

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CENTURY MODEL 409D RECORDING OSCILLOGRAPH

Numerous agencies engaged in the manufacture and evaluation of missiles have turned to the Century Model 409D Recording Oscillograph as a reliable means of collecting missile performance and control data.

On-board mounting eliminates the necessity for the costly and often not reliable RF link.

The ruggedness and reliability of this 12-channel oscillograph have been demonstrated many times. One agency reports having recovered 42 satisfactory record rolls out of 43 firings. Another, using special mounting configuration, reports recording at 60 G's without damage.

This 13 lb. instrument is compact enough to be installed in most missiles and all electrical connections including remote control are accomplished through a single multi-pin AN connector.

Wire, Write or Phone

CENTURY ELECTRONICS & INSTRUMENTS, INC.

1333 North Utica, Tulsa, Oklahoma

Circle No. 43 on Subscriber Service Card.

severe vibration, impact and shock, will accept 50′ and 100′ daylight loading magazines. This feature eliminates one of the photographer's major problems in location work.

Circle No. 259 on Subscriber Service Card.

MAGNETIC COUNTER

Model MCRP-700 by Photocon Research Products is a compact, high-speed, precision counter developed to add or



subtract electrical pulses with optional microswitch control at zero level—featuring electrical reset to any predetermined number.

The high-speed lightweight armature, which actuates the counting mechanism, is dynamically balanced to provide accurate counting under severe vibrations.

The MCRP-700 can be furnished as a three, four, or five digit counter with any combination of add, subtract, and microswitch control at zero level.

Circle No. 249 on Subscriber Service Card.

PRESSURE CONTROLLER

Bellofram Type air gauging manostat is said to give precise downstream pressure control over wide supply pressure variations. It does not drift with time or with periodic shutdowns. It remains precisely stable through tempera-



ture changes as well as supply or flow variations.

Manufactured by Bellofram Products Corp., the manostat utilizes an extremely high gain servo system with main valve action controlled by a pilot nozzle which in turn is activated by slight pressure variances. Instantaneous adjustment

of controlled pressure is assured by the small relative movement required between the pilot valve and its seat in order to initiate great changes in main valve action.

To eliminate exhaust valve "pick-up" on dead-end service and initial drop-off, pilot pressure is bled directly to atmosphere rather than downstream.

Manostat's entire measuring element, including the pilot valve, embodies highly elastic metallic parts having practically no hysteresis or permanent deformation under any working conditions.

Resolution is one-part-in-10,000 of range, and repeatibility is usually less than one in 5,000 of range.

Available in ranges of 2-25 and 3-36 psi in 1.8" and ¼" pipe sizes.

Circle No. 264 on Subscriber Service Card.

SAMPLING SWITCH

A precision switch having a hermetically sealed case for high altitude mili-



tary and commercial applications has been developed by General Devices, Inc.

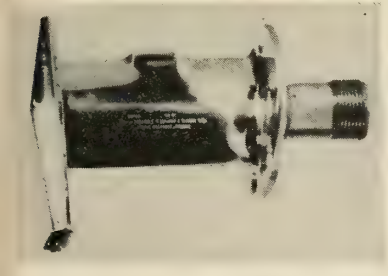
The switch has up to two poles with 30 non-shorting channels per pole. It is driven by either 28 vdc motor with a governor, arc-suppressor and a R.F. filter or a 115 v, single phase, 400 cps hysteresis synchronous motor.

Dimensions are 2.75" x 4.94" x 3.87". Typical applications include high altitude telemetry systems, multi-channel data systems, error indicating systems, etc.

Circle No. 247 on Subscriber Service Card.

TEMPERATURE PROBE

Rosemount Engineering Co. claims its Model 102 is the fastest total temperature

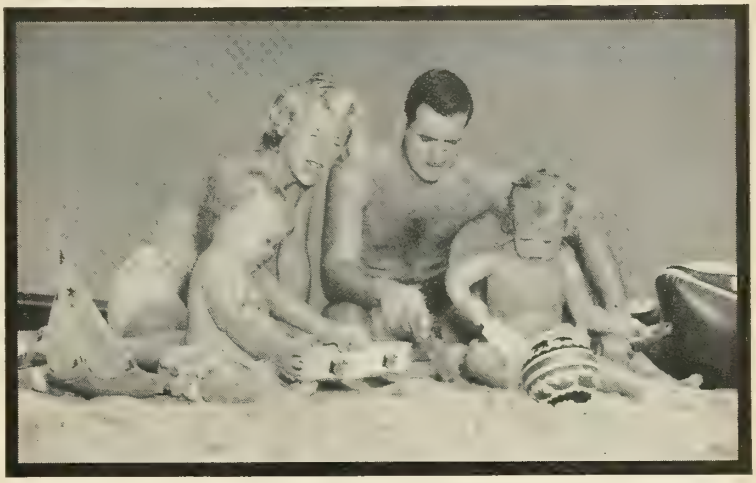


probe designed specifically for flight test applications. Time constant for the probe is less than 25 milliseconds under most conditions of operation.

The 102 exhibits extremely small recovery errors, namely, less than .1% of the absolute temperature for supersonic flight, and even less for subsonic flight.

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Design of the unit protects the element from flying particles. This is done by removal of internal boundary layer air, thereby avoiding the usual upstream particle deflector which is slow in response and contributes a slow transient into the response of ordinary "fast" designs, the company reports.

This design eliminates all but the finest water droplets. Further testing is expected to show dry adaabatic readings in rain.

Model 102 probe has 50 ohm platinum resistance thermometer element, and has excellent uniformity of calibration. The element may be easily replaced and repaired at low cost. The element also has long electrical leakage paths for minimum dependence or dampness.

Circle No. 237 on Subscriber Service Card.

HEAT TREATABLE ELECTRODE

Eutectic Welding Alloys Corp. has developed a fully heat treatable all-position electrode formulated specifically for fabrication of chrome-moly steel and other high tensile alloy steels.

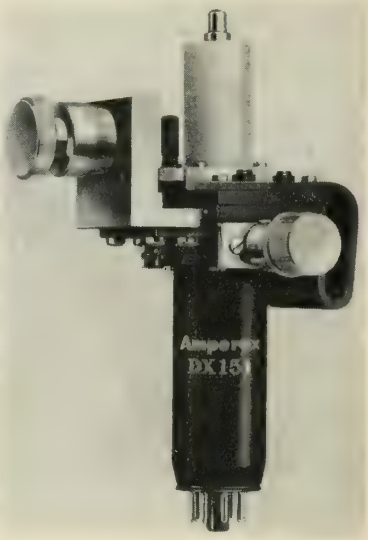
Featuring ease of application regardless of current or position, "Low Amp" EutecTrode 71 ac-dc is designed mainly for low alloy steels, particularly the 4130, 4140 and 8630 grades. Deposits have similar heat treating characteristics as the base metal.

The electrode has a deposited tensile strength of 100,000 psi. Deposits are fully heat treatable. Specific uses for spatter and clag interference-free Eutectrode 71 ac-dc include fabrication of tanks, containers and vessels for high pressure work.

Circle No. 243 on Subscriber Service Card.

KLYSTRON

A new 4mm klystron tunable over a range of 6 kmc from 65.5 to 77.5 kmc



has been announced by Amperex Electronic Corp. The DX151 waveguide-output reflex klystron has an output of 40 milliwatts at band center and 10 milliwatts across the band.

Oxide coated cathodes are used and operate at 2 to 4 amps per square centimeter and are said to give long life. Heater power needed is 0.4 amperes at 10 volts ac or dc. Electrostatic focusing is used.

Circle No. 228 on Subscriber Service Card.

SNAP-ACTION SWITCH

Milli-Switch Corp. has developed a hermetically-sealed high-amperage snap-action switch which is said to insure reliability and performance because of a one-piece spring.

Model BHA-HS has an electrical rating of 10 amperes at 30 vdc resistive, 8 amperes at 30 vdc inductive and 10 amperes at 125 vac. Temperature range is —67°F to 268°F; operating force, 30 oz. maximum to 4 oz. minimum release force; vibrations, 55 to 4,000 cycles per sec.; shock, 75g.

Contacts are fine silver, 24 karat gold-plated; terminals are screw type 24 karat gold-plated over silver plate. Altitude to 100,000 ft.; life is 250,000 cycles minimum mechanical. The mounting bracket is corrosion resistant.

Circle No. 252 on Subscriber Service Card.

TEFLON HOOK-UP WIRE

Made to MIL-W-16878B and meeting all requirements of this specification, Amphenol high temperature Teflon Hook-Up Wire is being marketed by Amphenol Electronics Corp.

Types E and EE and a variety of colors and gauges are represented in the line.

Amphenol reports the following features: ease of processing in automatic stripping machines because of concentricity of Teflon insulation over tightly

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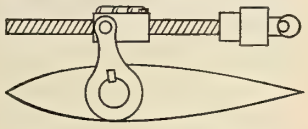
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FAIL-SAFE ACTUATION

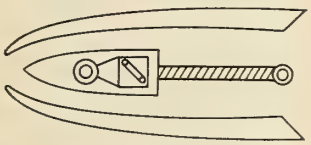
for guidance and control in difficult environments with SAGINAW b/b SCREWS and b/b SPLINES



TYPICAL APPLICATIONS

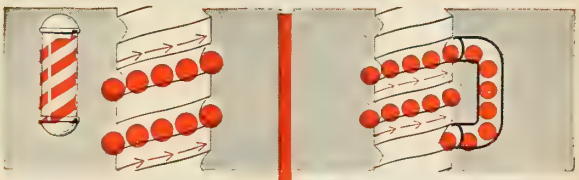


Control surface actuators



Nose cone positioners

Evelon positioners • Afterburner controls • Speed brake actuators • Rocket engine displacement actuators • Clamping mechanisms for missile boosters • Fuel controls (3-dimensional cams) • Black box tuning devices—telemetering and guidance systems • Antenna coupler tuning mechanisms



Nut *glides* on steel balls. Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.

At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

1 VITAL POWER SAVINGS. With guaranteed efficiency of 90%, Saginaw b/b Screws are up to 5 times as efficient as Acme screws, require only ⅙ as much torque. This permits much smaller motors with far less drain on the electrical system. Circuitry is greatly simplified.

2 SPACE/WEIGHT REDUCTION. Saginaw b/b Screws permit use of smaller motors and gear boxes; eliminate pumps, accumulators and piping required by hydraulics. In addition, Saginaw b/b Screws themselves are smaller and lighter. Units have been engineered from 1½ in. to 39½ ft. in length.

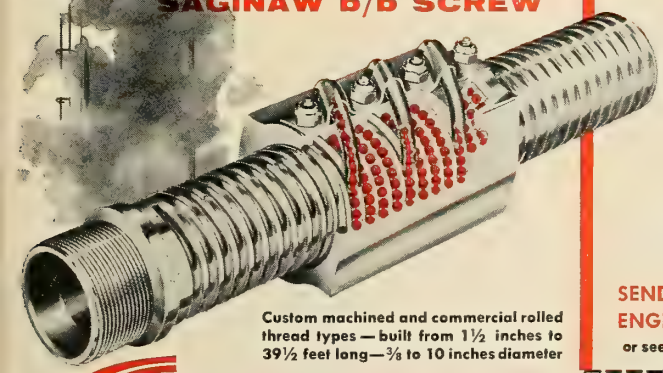
3 PRECISE POSITIONING. Machine-ground Saginaw b/b Screws offer a great advantage over hydraulics or pneumatics because a component can be positioned at a predetermined point with precision. Tolerances on position are held within .0006 in./ft. of travel.

4 TEMPERATURE TOLERANCE. Normal operating range is from −75° to +275° F., but assemblies have been designed in selected materials which function efficiently as high as +900° F. These units are practical where hydraulic fluids have lost efficiency or reached their flash point.

5 LUBRICATION LATITUDE. Even if lubrication fails or cannot originally be provided because of extreme temperatures or other problems, Saginaw b/b Screws will still operate with remarkable efficiency. Saginaw units have been designed, built and qualified for operation without any lubrication.

6 FAIL-SAFE PERFORMANCE. Far less vulnerable than hydraulics. In addition, Saginaw offers three significant advantages over other makes: (1) Gothic arch grooves eliminate dirt sensitivity, increase ball life; (2) yoke deflectors and (3) multiple circuits provide added assurance against operating failure.

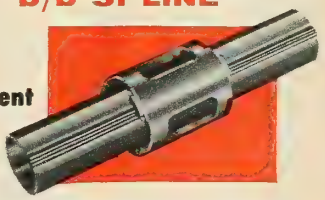
SAGINAW b/b SCREW



Custom machined and commercial rolled thread types — built from 1½ inches to 39½ feet long—⅜ to 10 inches diameter

SAGINAW b/b SPLINE

Averages 40 times lower friction coefficient than sliding splines



Radically increases efficiency of transmitting or restraining high torque loads; built from 3 inches to 10 feet long, ⅜ to 6 inches diameter

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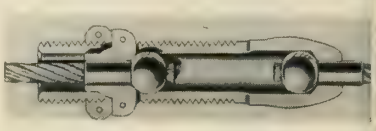
stranded wire; ease of tinning because of minimum of 40 micro-inches silver-plating on all wires; assured reliability because of 100% inspection of every foot produced, including 11 major quality checks.

Circle No. 251 on Subscriber Service Card.

SHORT TURNBUCKLE

A short turnbuckle which exceeds standard tensile and fatigue strength requirements has been developed by Voi-Shan Manufacturing Co.

One-third as long as the standard AN short turnbuckle, the new one, called



Cabuckle, has constant length for any adjustment. It can be installed and adjusted readily with standard tools, eliminates cable twist, and can be lock-wired.

Cabuckle assembly has three components: slotted sleeve with rolled external threads, a forged cross-piece, and a hex nut. One cable end is attached to the sleeve, the other to the cross-piece. Cable tension is adjusted by advancing the nut on the sleeve and the amount of available adjustment is visible at all times.

Voi-Shan, division of the Pheoll Manufacturing Co., is licensed by North American Aviation Co. to develop and manufacture Cabuckle, NAA designed Cabuckle to meet a space-limit problem in the flight control system for the F-100 fighter-bomber.

Circle No. 257 on Subscriber Service Card.

OXY-ACETYLENE REGULATORS

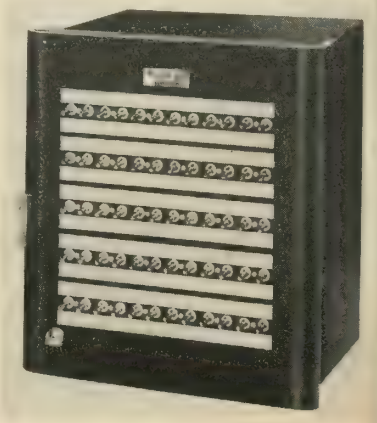
A new line of "Jet-Flow" oxygen and acetylene regulators for gas welding has been developed by Marquette Manufacturing Co.

The new regulators are offered in several price ranges and in many sizes, both single and two-stage. New design contains only four working parts, assuring long life and maintenance-free operation. Each regulator in the new line is "proof tested" in the factory under actual operating pressures to assure perfect operation.

Circle No. 236 on Subscriber Service Card.

PYROMETRY CIRCUIT SWITCHES

Thermo Electric Co., Inc. has developed a line of key-type selector switches



for connecting sensing elements to indicators, recorders or other instruments. Two-position and three position key switches with various pole arrangements are available.

Cases containing the switches are moisture-proof and dust tight and suitable for wall or panel mounting. Case capacities range from 12 to 144 points for both thermocouples and resistance bulbs.

Circle No. 231 on Subscriber Service Card.

ANGLE ATTACHMENTS

A line of angle attachments, designed to simplify production fastening in close



quarters and hard-to-reach places, has been developed by Gardner-Denver Co.

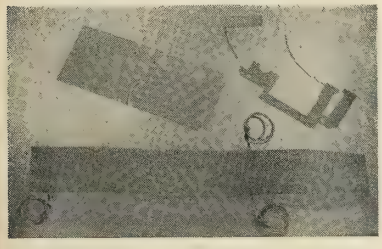
Four attachments, for use with the recently developed line of Keller Tool air drivers, are heavy or light duty angle screw drivers and nut setters.

Newly designed Keller No. 2 air motors power both the 12G-2 series screw drivers and the 16G-2 series nut setters. These air motors, it is reported, provide more speed, increased power, low noise level and low maintenance.

Circle No. 245 on Subscriber Service Card.

WOVEN ELECTRIC HEATERS

Thin enough to fit into cramped instrument spaces, flexible enough to be bent around sharp corners, and availability in practically any physical shape are claimed to be advantages of a new group of heaters that permit wide design of flexibility in adapting electric heat.



Designated Pre-Fab Laminated Woven Electric Heaters, they are custom-made by Pre-Fab Heater Division, Chromalox, Inc.

Heaters may be insulated with silicone-rubber, Neoprene, natural rubber and synthetic rubber. Maximum heater surface temperatures are 150°F with natural or synthetic rubbers, 167°F with Neoprene, and 350°F with silicone-rubber insulation. They may be applied with adhesives and by bonding and clamping. Leads may be insulated with silicone, Teflon, neoprene or rubber, depending on the construction of the heated sections.

Widths of the Pre-Fab heaters range from ⅜" to 24", while maximum length

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BEAN

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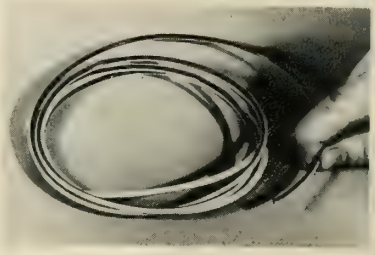
is 24″. Thickness is determined by wire size and insulation; minimum is .020″.

Wattages range from fractional up to 15 watts per sq. in., while higher watt densities may be built in if heat take-away rate is sufficient to keep temperature of insulation below the breakdown point. Voltages are 6, 12, 24, 48 and up to 230 v. and also 440 v for special applications.

Circle No. 239 on Subscriber Service Card.

STRIPED TEFLON TUBING

Pennsylvania Fluorocarbon Co., Inc. is marketing Teflon tubing with axial stripes of any color to make it easier to

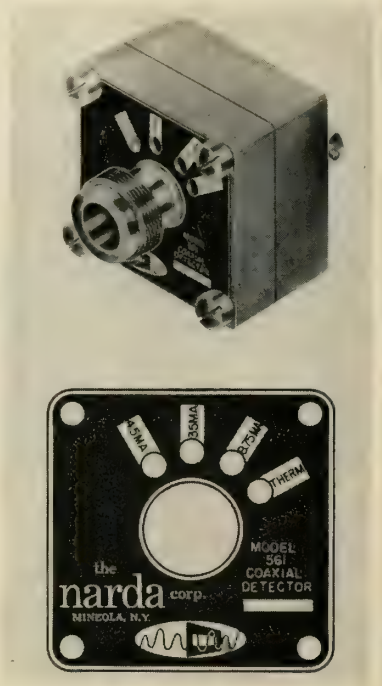


identify process lines, electrical and electronic leads. Available in any size, the tubing has good dielectric strength (500 to 1,000 v/mil); lowest dielectric constant (2.0) and dissipation factor (0.0002) of any solid dielectric; no change of electrical properties with temperature or frequency.

Circle No. 220 on Subscriber Service Card.

COAXIAL DETECTOR

A new coaxial detector mount for bolometers and thermistors of the mica



disc type which requires no tuning and covers the frequency range of 500 to 10,000 mc. has been developed by Narda Corp.

The new mount, Model 561, uses a unique arrangement of the locating pin



K.O. PUNCH...



from Army Ballistic Missile Agency

This is the REDSTONE missile . . . a real knockout for anyone who tries to get tough with Uncle Sam.

Reynolds Aluminum Fabricating Service, as both a prime and subcontractor, is proud to work with the Army Ballistic Missile Agency in the development and production of these missiles . . . our Army's new K.O. punch. Reynolds is proud to work with the scientists, the engineers and the more than 3,500 civilian and military personnel of the A.B.M.A. – one of the activities located at the Redstone Arsenal.

Reynolds offers to this field production redesign, an engineering staff experienced in the development of highly specialized jigs and fixtures, welding techniques, optical inspection equipment, use of X-ray facilities and – the latest in aluminum developments and applications.

Reynolds Aluminum Fabricating Service

LOUISVILLE 1, KENTUCKY

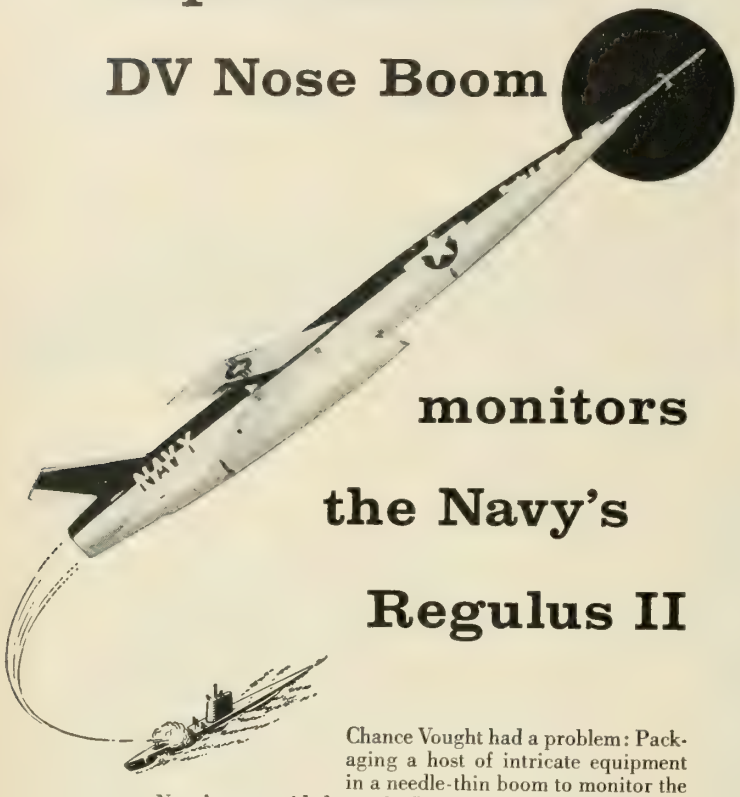
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FORMING • ROLL SHAPING • WELDING • BRAZING



See "CIRCUS BOY", Reynolds exciting dramatic series, Sundays, NBC-TV

Another **DALMO VICTOR** *achievement*

Super-sensitive DV Nose Boom monitors the Navy's Regulus II



Chance Vought had a problem: Packaging a host of intricate equipment in a needle-thin boom to monitor the Navy's new guided missile, Regulus II. This "packaging" was additionally complicated by the requirement that to conserve storage space on board a submarine, the boom must fold pneumatically by remote control.

Dalmo Victor's engineering skill, acquired through development of airborne radar scanner designs, provided the answer!

The ten-foot DV pitot static boom, as accepted by the Navy, meets these most exacting design requirements and provides vital data, including airspeed and altitude, as well as angles of attack and yaw.

Long-recognized leader in airborne radar antennas, Dalmo Victor now applies its experience and skills to create missile components. Contact the nearest DV office for help in solving similar problems.

DV



DALMO VICTOR COMPANY

Division of Textron Inc.

BELMONT, CALIFORNIA

SALES: Dayton, Los Angeles, Washington
FIELD SERVICE: Baltimore, Belmont

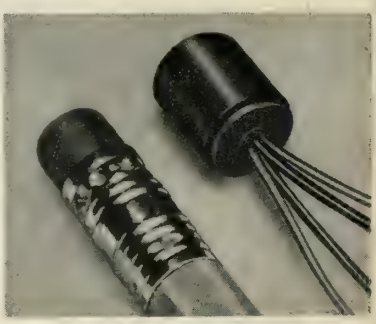
Circle No. 45 on Subscriber Service Card.

plus a "locator" coded nameplate which is a functional part of the instrument that makes it possible to change elements rapidly and to determine quickly which type of element is in the detector and its bias requirements.

Circle No. 232 on Subscriber Service Card.

TRANSISTOR TRANSFORMERS

Seven new types of transistor transformers have been added to the United Transformer Corp's line of ultra-miniature DO-T units. The units weigh one-



tenth ounce and are fully hermetically sealed to MIL-T-27A specifications.

Included in the new group are 500 milliwatt types designed for pushpull transistor to 600 ohm line operation, a chopper input transformer, transistor interstage transformer, and a line-to-line matching transformer.

Circle No. 222 on Subscriber Service Card.

SILICONE RESIN

Dow Corning Corp. has developed a silicone resin that is said to establish new performance standards for high-temperature protective coatings. Identified as Dow Corning 808 resin, it provides greater gloss retention after long exposure to high temperature than was previously possible.

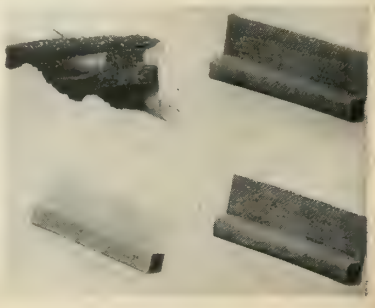
Typical formulation pigmented with titanium dioxide and thinned with xylene, retains its original 84% gloss rating after 100 hrs. at 482°F. When subjected to 572°F for 400 hrs, or to 482°F for over 2,500 hrs., its gloss rating drops to 70%.

Circle No. 201 on Subscriber Service Card.

FABRIC SEALS

Fuel-resistant, fabric-covered and fabric-reinforced seals for —65°F to 400°F applications are being produced by The Connecticut Hard Rubber Co. using LS-53, Dow Corning's new Fluoro-silicone rubber.

The fabric-covered seals provide high tear and abrasion resistance. The LS-53 fluoro-silicone rubber remains resilient, resists swelling and destruction by aviation



fuel and synthetic oils, even at extreme temperatures.

While the LS-53 fluoro-silicone rubber costs considerable more than ordinary silicone rubber, fabric-covered or fabric-reinforced seal constructions provide the most practical and economical use of the rubber.

The seals, custom made to meet customer design requirements, are already being produced for aircraft uses.

Circle No. 254 on Subscriber Service Card.

DIGITAL-ANALOG CONVERTER

A Multiverter for analog to digital and digital to analog conversion has been



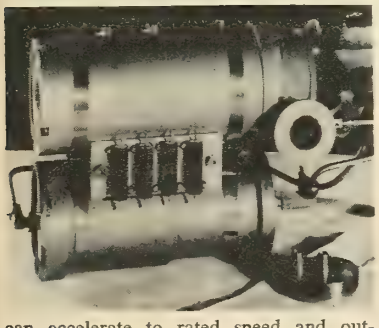
developed by Packard-Bell Computer Corp. subsidiary Packard-Bell Electronics Corp. Conversions are said to be provided at better than 0.01% and at speeds in excess of 15,000 per sec. for analog to digital and 300,000 per sec. for digital to analog conversion.

The unit is completely transistorized. It is claimed to be the first commercially available converter of its type that permits multiplication and division in the process of conversion.

Circle No. 230 on Subscriber Service Card.

POWER UNIT

General Electric Co. has produced a fully self-contained electric and hydraulic auxiliary power unit for missiles. It



can accelerate to rated speed and output within half a second.

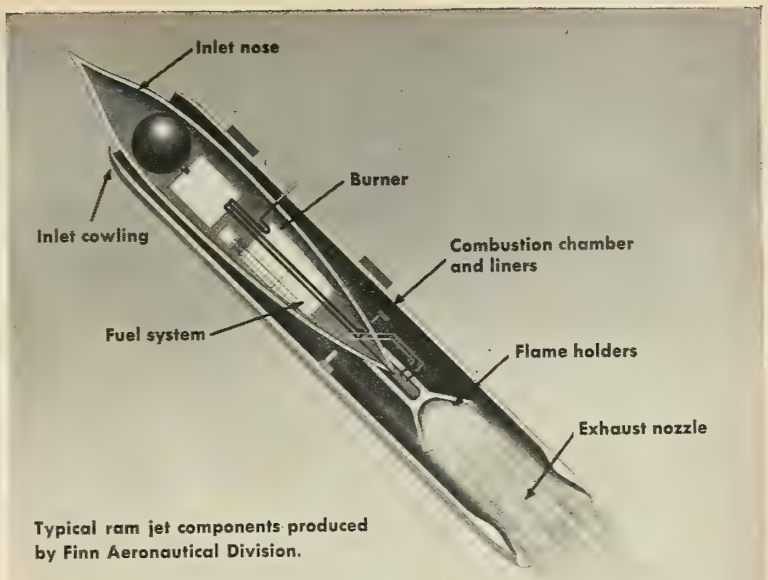
The compact, turbine-drive unit consists of several modular components for versatility and flexibility of outputs and can supply electric power, hydraulic power, or both with ratings from 1.5 hp to 10 hp.

Circle No. 248 on Subscriber Service Card.

BALANCE UNIT

Ten 4-arm strain gauge bridge or resistive type pickups may be calibrated individually or simultaneously with a rack-mounted balance unit manufactured by Consolidated Avionics Corp.

Designed for large-scale instrumentation systems, Model 228 employs individual plug-in calibration resistors



Typical ram jet components produced by Finn Aeronautical Division.

We specialize in precision welded sheet metal components for missiles, jets and ram jets

We have the experience, the equipment, the men and the approvals to carry out your most complex experimental welding and fabrication of jet, ram jet and missile engine components.

Some of the superalloys we've worked and welded include N-155... A-286... the Nimonics... Inconel-X... Inconel-W... Hastelloy... Timken... and stainless steel. Our welding department includes certified Sciaky spot welders, USAF certified heliarc welders and complete, USAF-approved X-ray facilities.

For more detailed information, write, wire or 'phone us.

FINN AERONAUTICAL DIVISION

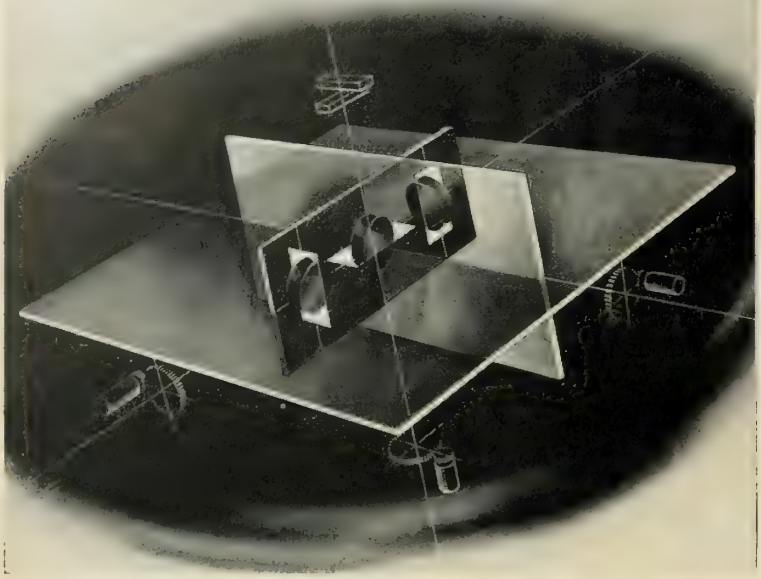
T. R. FINN & COMPANY, INC.

275 Goffle Road, Hawthorne, N. J.

HAwthorne 7-7123

Check the plus values of **BERYLLIUM**

FOR INERTIAL GUIDANCE SYSTEMS . .



miniature, light-weight, highly accurate controls are possible through use of BRUSH QMV BRAND BERYLLIUM

The unique physical properties of BRUSH QMV BERYLLIUM contain *bonus* values for designers of missiles and missile guidance devices.

RIGIDITY, DIMENSIONAL STABILITY and MACHINABILITY allow design *and* manufacture of highly accurate systems without the bulk and weight usually associated with guidance accuracy.

HIGH STRENGTH and LIGHT WEIGHT permit design of components and structures for best fuel efficiency and increased payload of the missile.

HEAT CAPACITY, THERMAL CONDUCTIVITY and HIGH MELTING POINT make BERYLLIUM ideal for use under intermittent or steady thermal loads.

✓	RIGIDITY—44.3 x 10^6 psi
✓	LIGHT WEIGHT—1.85 g/cc
✓	TENSILE STRENGTH—45,000 psi
	GOOD CORROSION RESISTANCE
✓	EXCELLENT STABILITY
✓	HIGH HEAT CAPACITY
	COMPRESSIVE YIELD STRENGTH—30,000 psi
✓	HIGH THERMAL CONDUCTIVITY
	LOW NEUTRON—CAPTURE CROSS SECTION
	HIGH NEUTRON—SCATTER CROSS SECTION
	HIGH MELTING POINT—2345°F
✓	GOOD MACHINABILITY
✓	CO-EFFICIENT OF EXPANSION—6.4 x 10^6 in/in/°F

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THE BRUSH BERYLLIUM COMPANY, 4301 PERKINS AVE., CLEVELAND 3, OHIO

which are inserted from the front through a hinged door on the panel. Precision 10-turn balance and sensitivity potentiometers are provided with knurled finger locks for



maintaining desired settings. Toggle switches permit individual transducer calibration, or all transducers may be calibrated by a remote contact closure.

Individual or common voltage supplies of 0 to 30 v may be used. The system is designed for 4-arm resistive transducers of 120 ohms or more.

Model 228 supplements the manufacturers line of airborne calibration systems which are available in 16, 26 and 36 channel models.

Circle No. 262 on Subscriber Service Card.

SQUARE CR TUBE

Electronic Tube Corp. has announced a new 3½" square-face Type 41HAP

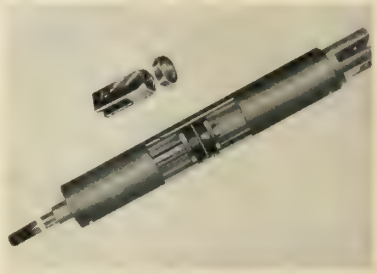


single-gun electrostatic focus and deflection cathode ray tube. Overall length is 11⅛". Traces are held within 1 degree of each other and deflection factor is held to within 10%. A low current gun is used.

Circle No. 229 on Subscriber Service Card.

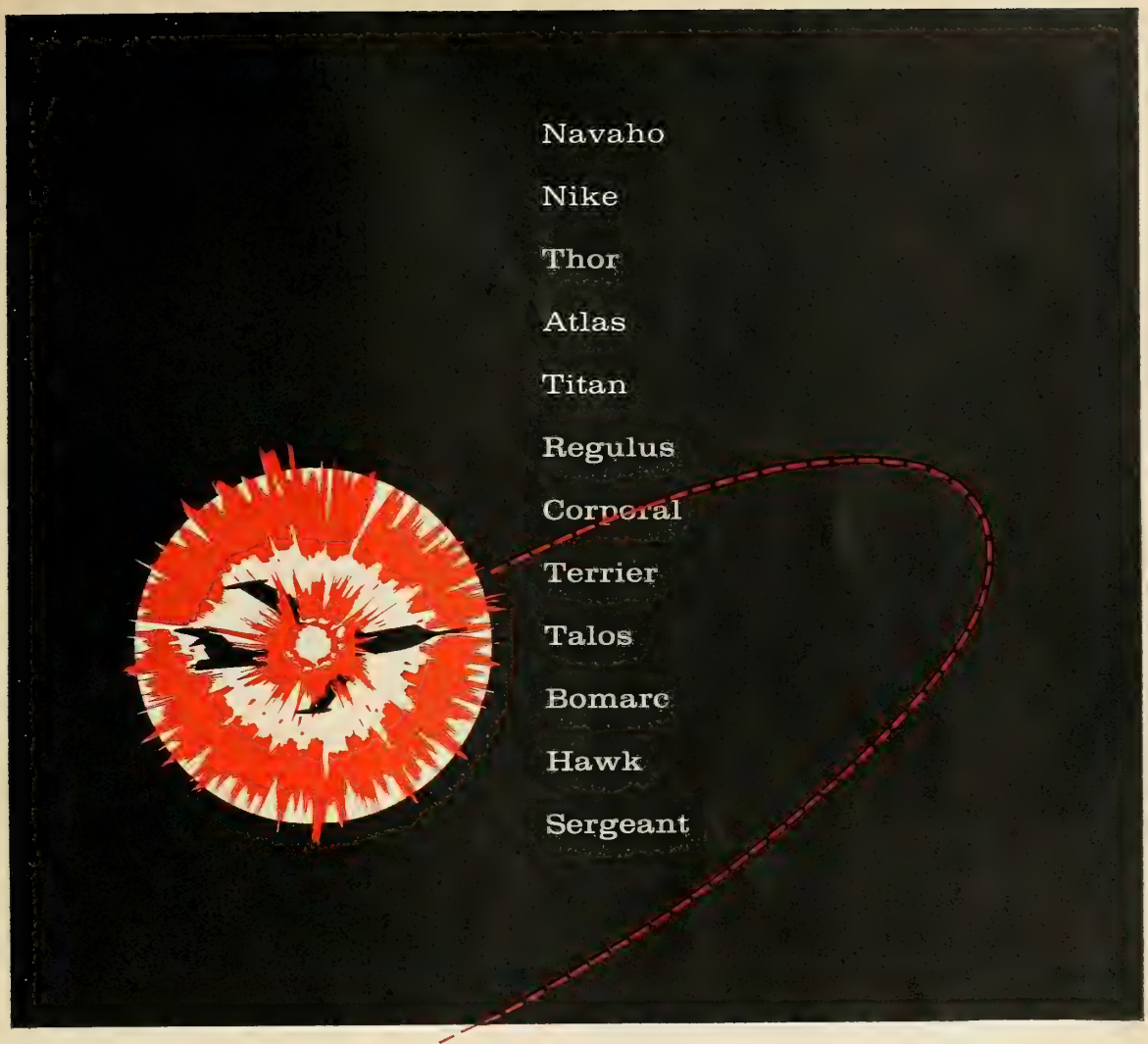
CYLINDERS

Two lines of cylinders, known as types AN and BN are being manufactured by the A. K. Allen Co. Both models feature a fork-type rear head for mounting, stainless steel rods, Nylined bearings, high tensile aluminum heads, honed brass or steel tubing treated for corrosion re-



sistance, and a choice of fixed or adjustable cushions for either end or both.

The bore sizes available are: ⅞", 1⅛", 1½", 2" 2½", 3" and 4". Type





LOAD! AIM! FIRE! automatically with VICKERS

hydraulic systems for missile handling and launching . . .

Name an important missile. Chances are that Vickers equipment or "know-how" played a part in its success. Every one of the missiles listed above, for example, depends on Vickers hydraulic units for some phase of surface handling, launching or testing.

Latest development is a completely integrated hydraulic system that brings true automation to missile handling. At the push of a button, missiles automatically flow from storage rack to final firing position.

There are important reasons for Vickers' success in heavy ordnance work. Long experience in this specialized field is one. Another is the fact that Vickers has the most comprehensive line of hydraulic equipment.

Hydraulics itself has unique advantages. On a recent project, a 100-horsepower transmission offered the ideal solution because of: —

High torque to inertia ratio — the pump end can be stroked from zero to maximum displacement in less than 30 milliseconds.

High power gain — a milliwatt input easily controls hundreds of horsepower.

Very narrow deadband — narrower than any other high horsepower drive.

High horsepower to weight ratio.

For one source convenience and one source responsibility, bring all your hydraulic problems to Vickers.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION

Marine and Ordnance Department
Waterbury 20, Conn.



When tomorrow's rocket takes off for a destination in space, its propellant will undoubtedly be a high energy fuel-oxidant system . . . and the oxidant may well be ozone.

In the comparatively short period since the development by Welsbach of dependable tonnage ozonators, the applications of this versatile low-cost oxidant have broadened to include practically every industry. It is recognized for its specificity and purity in chemical synthesis reactions and has made possible increased yields of high quality products from cheap and abundant raw materials.

Specific uses for Welsbach ozone include the production of lubricants for high-speed motors and jets and the oxidation of corrosive chlorides in nitric acid recovery following atomic fuel extraction. Ozone also effectively removes phenol and cyanide from industrial wastes, and improves the oxidation characteristics of mineral oils.

These and numerous other uses indicate that the scope of applications for Welsbach ozone is unlimited. Through constant research, Welsbach continues to enlarge the field for ozone as an oxidant. With an unparalleled background in the design and construction of tonnage ozone plants, Welsbach offers you a long and varied experience in ozone application.

Call or write us today for help in solving your oxidation problem.



Write for this booklet on Welsbach Ozone Generation for Industrial Application. Please indicate company and title.

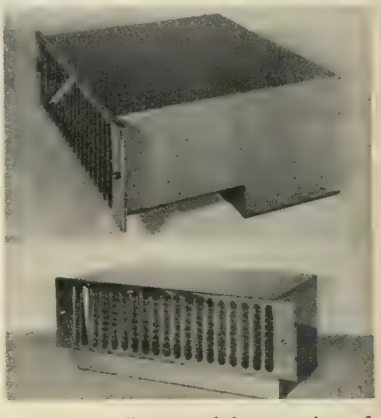
THE WELSBACH CORPORATION
OZONE PROCESSES DIVISION
DEPT. 604, 15th & WALNUT STS.
PHILADELPHIA 2, PENNSYLVANIA

BN cylinders use cups for the piston head seals instead of the O-ring packing used in type AN. Double packing for the rod gland is also provided on the Type B. All cylinders are available as double acting or single acting spring return.

Circle No. 256 on Subscriber Service Card.

FILTER AND BLOWER

Packaged blowers are available in several sizes to utilize minimum of panel height in electronic rack from McLean Engineering Laboratories. Filter and blower section was designed to protrude

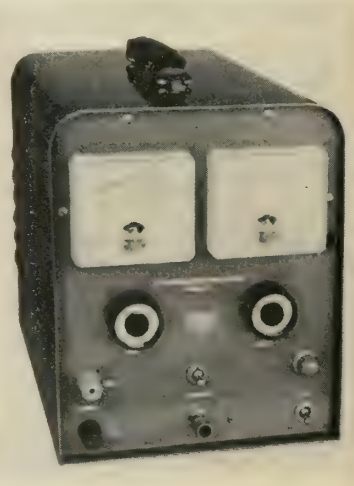


in the normally unused base section of the rack since blower is normally the bottom component of a relay rack. Models 2P408 and 2Q408 require 5¼2 on panel height but have performance of models requiring more height. Unit will dissipate a 1.5 kw heat load with an air temperature rise of 10°C.

Circle No. 211 on Subscriber Service Card.

ULTRASONIC GENERATOR

Ultra-regulated low voltage dc power supply developed by Optimized Devices, Inc. utilizes an ultrasonic carrier sys-



tem to achieve optimum performance consistent with light weight, compactness, and efficiency. This supply, which can produce 0 to 7 v at up to 1.5 amperes, is said to be superior to batteries in almost all applications.

Typical uses are for strain gauges,

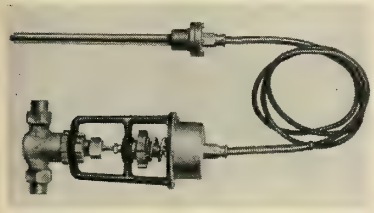
dc filaments, transistors, precision electroplating, bias supply, and for a precision laboratory reference even under load.

A number of feedback loops and corrective networks combine to keep the output voltage virtually independent of line and load fluctuations. Regulation is complete even down to O v. Negative voltage feedback is included for low drift, low noise, and low output impedance. Adjustable current feedback is included to reduce the output impedance to O ohms. The adjustment can also provide a negative resistance characteristic to compensate for lead length.

Circle No. 246 on Subscriber Service Card.

TEMPERATURE REGULATORS

Watts Regulator Co. has a new line of single seated temperature regulators for automatic flow regulation of liquids or



steam. These self-operating regulators are of two types—direct acting and reverse acting.

Direct acting regulators maintain the liquid temperature by controlling the heating source. They are available in sizes ½″ to 1½″ inclusive. Reverse acting regulators maintain the liquid temperature by controlling the cooling source. They are available in sizes ½″ to 1″.

Both types are easily adjustable for temperature control within 40°F operating range within 100°F and 240°F. They feature overheating protection and rugged bronze body construction with replaceable stainless steel seats.

Circle No. 235 on Subscriber Service Card.

HIGH-TEMPERATURE OSCILLOGRAPH

A new recording oscillograph developed for flight testing at high temperatures is now available from Consolidated



Electrodynamics Corp. The Type 5-112 is able to operate from —65°F to 250°F at altitudes to 120,000 feet.

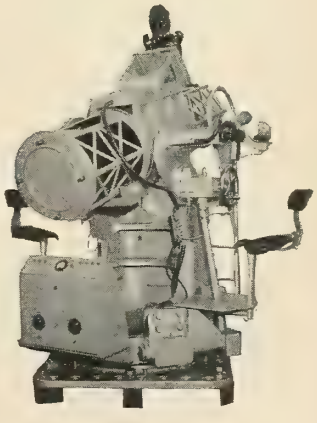
The unit is explosion-proof and features a crash resistant magazine with



This precise sidereal rate table so accurately counters the earth's rotational rate that the test platform in effect stands still in space. A primary standard for testing navigational systems and components, this sidereal table is only one of a series of direct and servo driven rate tables available.

Foremost in the field of range instrumentation, Fecker offers missile tracking telescopes, special cameras, photo-theodolites and complete synchronizing and control systems.

For additional information or assistance with any special problem simply write.



j. w. fecker, inc.

A Subsidiary of AMERICAN OPTICAL COMPANY

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Circle No. 47 on Subscriber Service Card.



New **VAN TRAILER** by Craig
houses all this equipment . . . with room to spare!

There's plenty of room inside the new insulated Craig Van Trailer LM-105! With its big 5,000 pound payload and roomy 575 cubic foot interior, this rugged van trailer can house 12 standard 6-foot racks, fully loaded with electronic equipment—and still allow ample space for operation and maintenance.

Whatever the load — a complete electronic system, test equipment, mobile maintenance shop, or you-name it—your equipment arrives quickly and safely in the LM-105. This versatile van trailer meets Government specifications for world-wide, all-weather use.

Quick facts about the LM-105:

WEIGHT: Approximately 4,000 pounds including dolly.

PAYLOAD: 5,000 pounds.

DIMENSIONS: (Inside) 140 inches long, 90 inches wide, 79 inches high.

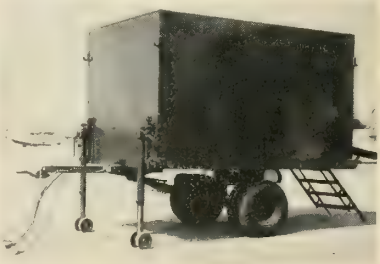
INSULATION: overall shelter has U-Factor of 0.30.

FEATURES INCLUDE: aluminum-faced honeycomb panel construction; lighting system; power distribution box; cable entry ports; stairs; jacks for levelling; and a quickly detachable dolly with coil spring and torsion bar suspension, air-over-hydraulic brakes, and single beam towing tongue.

ACCESSORY EQUIPMENT AVAILABLE: includes air conditioner, heater, workbench, racks, cabinets, spare parts containers, etc.

AIR TRANSPORTABLE: By C-119 or larger cargo aircraft.

ELECTRONIC INSTALLATION: Craig provides complete layout and installation of equipment including wiring and component check-out.



Van Trailer LM-105, front view, with jacks in position.

For further information, write Craig today!

Craig SYSTEMS, INC. *Dept. L-7, Danvers, Mass. Tel.: SPring 4-1870*

WESTERN DIVISION: *6214 West Manchester Avenue, Los Angeles, 45, California ORegon 8-0025.*

OTHER CRAIG PRODUCTS . . . . *transportable and mobile electronic systems, shelters, trailers, vans, mobile control towers, missile carriers, re-usable containers, antenna towers and masts.*

Circle No. 48 on Subscriber Service Card.

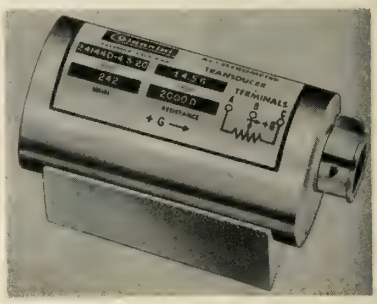
a safety shutter that automatically closes when the magazine is removed from the oscillograph.

Up to 26 channels can be recorded at writing speeds in excess of 12,000 inches per second. The unit occupies less than one cubic foot of space. Twelve discrete record speeds give a range of 0.047 to 96 inches per second. A jump-speed system allows the operator to pre-select jump speed ratios of 8:1, 4:1, or 2:1.

Circle No. 223 on Subscriber Service Card.

AXIAL ACCELEROMETER

A new line of axial accelerometers that feature extremely low cross-talk of



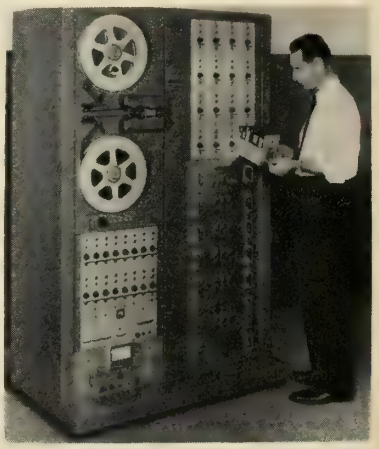
0.01g/g max. and low threshold has been developed by G. M. Giannini & Co., Inc. The units sense linear acceleration by a spring supported linear ballbushing mounted mass that moves along a shaft.

Output that is linear with acceleration is supplied by high resolution potentiometer pickoffs. Instruments are available with ranges of ±1g to ±40g with undamped natural frequencies from 7.8 to 54 cps.

Circle No. 227 on Subscriber Service Card.

MAGNETIC TAPE RECORDING

A bandwidth of 300 kc is featured in American Electronics Corp's new series 3000 multi-channel magnetic tape



recording system. Made by the Recordata Division of American Electronics, the system accommodates reel sizes to 14" and a single switch selects one of six standard speeds up to 60"/sec.

Module housings provide plug-in facilities for amplifiers and permit instant selection of direct FM or PDM recording or playback combinations.

Circle No. 224 on Subscriber Service Card.

TOP HAND

...on a test stand



Absolute tight shut-off reliability safety • long life



Absolute shut-off dependability and safety is assured with ANNICO TEFSEAL SEATS, proven in severe fuel, chemical and gas services at pressures to 10,000 psi.

ANNIN...*most widely used remote shut-off valves for control of liquid propellants*

ANNIN's ten years of experience in the design and development of valves for rocket and missile ground installations has resulted in a new valve concept which has been *proven-in-service* for remote, manual and throttling applications. ANNIN's complete line is now available for pressures to 10,000 psi and temperatures from −400°F to 1600°F. Write for catalog 1500-C containing data on ANNIN valve bodies, operators and special design features.

ANNIN *Control* **VALVES**

THE ANNIN COMPANY
DIVISION OF THE ANNIN CORPORATION
6570 Telegraph Road, Los Angeles 22, California

Circle No. 4 on Subscriber Service Card.



INDUSTRY SPOTLIGHT

By Norman L. Baker

Bell Aircraft Acquires Land for Research Center

BUFFALO—Bell Aircraft Corporation recently announced the acquisition of 350 acres of land near Pembroke on the New York State Thruway as a site for its new Lawrence D. Bell Research Center.

Two other significant developments were also revealed as part of Bell's program of consolidating its Niagara Frontier operations. They are:

1) Early completion of negotiations for a modern central warehouse on property purchased last year adjacent to the Wheatfield Plant.

2) Occupancy within 45 days of the new Electronic Data Processing Center now being finished at the Wheatfield Plant.

"With completion of the Research Center's first unit and occupancy of the new data Center, Bell Aircraft Corporation will own properties and equipment in the Niagara Frontier area valued at more than $34 million," President Leston Faneuf said.

"This does not include the new warehouse, which will be built by outside interests and leased back to Bell, nor the 12 government-owned or private properties now under lease to Bell," he continued.

"While we have been reducing our employment owing to changed Department of Defense requirements, we believe that construction of these new facilities, as well as other plans for the future, is concrete evidence of our corporate program to continue Bell Aircraft as a significant factor in the economic growth of the Niagara Frontier."

The site for the Research Center is located 1½ miles east of Pembroke on the Ontario section of the Thruway, near the junction of Routes 5 and 77 and was selected after several other sites had been investigated.

Initial expenditure for the research building will be $1 million. The first unit will be a hypersonic wind tunnel, capable of handling the highest speed ranges. This will be followed by a laboratory for heat studies and all services and facilities of the center will be available to other manufacturers.

Dr. Everett T. Welmers, formerly Bell's chief of dynamics, has been named director of the Research Center and is coordinating plans for the Center's design and construction, which will start this year.

A new $750,000 building will house the Electronic Data Processing Center, first occupancy to begin in August. The Data Center will handle all the computing in support of Bell's technical programs, including those of the Niagara Frontier Divisions, the Research Center and the Bell Helicopter Corporation in Fort Worth, Tex.

In addition to processing technical data, the facility will also maintain accounting records, provide manufacturing and financial records and a wide variety of other services and information for supervision and management. Eventually, it will also furnish similar data to Bell's wholly-owned subsidiaries.

The warehouse site is located north of the Wheatfield Plant on Walmore Rd. and adjoins Bell's railroad siding. The building will be approximately 250,000 square feet. Bell will occupy the facility on a lease-back arrangement. Construction is expected to be started within 60 days.

"The Data Center and the warehousing building are essential in our program of consolidation and cost savings," Faneuf explained.

"We have had computer operations in a number of departments and warehousing scattered in a number of locations throughout the Niagara Frontier. A centralized location for both functions will prove more efficient, more economical."

Aluminum Co. of America Develops New Impellers

Aluminum Company of America has developed "premium strength" high-speed aluminum impellers that have survived testing during which they were whirled at nearly three times the speed of sound.

The impellers, primarily intended for missile use, receive their high strength qualities through carefully controlled foundry practices and the fact that impurities are controlled to a new minimum, according to Alcoa officials. Iron content, for example is held to 0.2% in the improved alloys.

The alloy most used in the high-speed rotating parts is 355-T6—5% silicon, 1.3% copper, .5% magnesium, and the remainder aluminum and normal impurities. T6 designates solution heat treatment followed by artificial aging.

Alcoa has been spinning aluminum components for aircraft engine superchargers, propellers, jet engine turbines and torque converters since 1940, but the 2,000 mph speeds have not been common until recent development of the high-strength alloys.

During testing, parts are rotated in a "whirl pit" until they fly to pieces. Reassembled, the parts reveal valuable



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information to test engineers.

"Non-destructive" testing is done by coating the part with a brittle, lacquer-like substance and whirling it at speeds just short of the destruction point. Cracks in the coating show high stress areas.

Some parts have been spun without rupturing at peripheral velocities of 3,000 ft./sec.

Among the applications of the high-strength alloys in missiles are important structural castings for Douglas



Impeller mounted on test arbor at Alcoa laboratory. Part will be spun until it flies to pieces in "whirl pit."

Aircraft Co. Alcoa's high-strength casting process and Alloy A356-T61 give them some of the highest properties ever cast, according to a company official. In one case maximum tensile and yield strengths are 47.1 and 36.9 psi, elongation is 9%.

Lockheed Builds Lab For Missile Antennas

Lockheed Aircraft Corp.'s Missile System Division is building a facility for the design and testing of advanced missile antennas and radar devices.

Electronics experts and the division's antenna propagation department will be housed in the 10,000-sq.-ft. building at Sunnyvale, Calif. The site is located about a mile from present buildings at the division to minimize interference and improve accuracy of measurement in the study of radiation and propagation phenomena of electromagnetic waves.

Electronics Specialties Sales up 50% in '57

Electronics Specialties Co. sales this year are about 50% ahead of a year ago, according to William H. Burgess, president. Shipments for April and May ran above $400,000 monthly and the backlog is over $3 million.

ROCKET POWER PROGRESS REPORT

Atomic Radiation for Rocket Testing

by Alfred Cohen



Assistant Project Engineer in the Instrumentation Section of the RMI Test Department, Mr. Cohen is investigating new concepts for acquiring, reducing and evaluating test data. After graduating in mechanical engineering from City College of New York, he worked as a civilian test engineer for the Navy. Mr. Cohen came to Reaction Motors in 1954 as a Test Department Instrumentation Engineer.

Although the rocket engine in theory is an extremely simple powerplant, its development is a highly critical art. Successful operation of an engine depends upon the solution of many unique problems and the accurate measurement of unusual variables. One of the problems we encountered at RMI was the measurement of the corrosive effects of a new high energy rocket propellant, a problem we solved through the use of atomic radiation.

In determining the corrosive effects of propellants, it is essential that the sensing element employed does not come into direct contact with the propellant being tested. The propellant would rapidly damage or destroy most measuring equipment. In addition, the tolerance of the tests does not permit additional contamination from other foreign bodies.

We approached the problem on the basis that the density variation of the propellant could be the measure of its degree of corrosion upon the component materials with which it had been in contact . . . and the denser the material being tested, the less radiation would pass through it. We decided, therefore, to use the penetrating power of radiation as the tool to measure density variation.

To conduct the tests, a radioactive source and a detector for radiation were located so that the propellant being measured lay in a container between the two. The radioactive source emits gamma rays which penetrate through the propellant and its container. That part of the radiation that gets through the propellant and its container strikes the detector.

The detector contains a filling gas which is forcibly ionized when bombarded by atomic radiation. The energy of ionization is converted directly into electrical energy. Thus, an increase in the density of the propellant reduces the radiation field intensity at the detector, and results in a decreased generated signal.

However, accurate measurement of this energy is difficult because the generated signal is very low (in the magnitude of 1×10^{-13} amperes). To overcome this, an instrumentation system was specially developed to transmit, amplify and record this data.

The signal is transmitted to the amplifier by a special shielded cable that eliminates the effects of noise and other disturbances. Data is recorded by a Null system of measurement, using a ten-inch strip chart recorder. The recorder is calibrated to give full deflection for a density change equivalent to one tenth of a pound per cubic foot.

As a result of the data acquired by this test program, the research scientists have been able to improve the propellants to a point where they are both safe and highy desirable for use as rocket fuels.

This project is typical of one of the ways in which RMI Test Department supports the applied research, development and production projects associated with advanced rocket powerplants. All projects pass through this department, from the evaluation of components and fuels to the static "hot testing" of the entire engine system for an aircraft or missile before delivery.

The Test Department is staffed by a team of specialists highly qualified in mechanics, electronics, chemistry, and instrumentation. This team is constantly working to provide the most accurate possible test results and also to develop new equipment and methods that will allow for even more accurate information in the future. And—because this team is constantly expanding—we are always anxious to talk with top-rated engineers and technicians who are interested in test work.

4986

If you desire one or more reprints of Mr. Cohen's article, or would like to receive further information about employment at RMI, write to our Information Services Coordinator. Reaction Motors, Inc., 16 Ford Road, Denville, N. J.

Power for Progress



THE BIRD
THAT'S ATTRACTED TO STRANGERS

Audubon never observed it—this new species that won't tolerate intruders in the sky, tracks them down, destroys them.

Raytheon has pioneered in the development of electronic missile guidance systems for more than a decade. A technical milestone was reached when the Navy's experimental Lark, equipped with a Raytheon guidance system, achieved history's first destruction of an aircraft by a guided missile.

Today Raytheon, alone among electronics companies, is prime contractor for two missiles of advanced design: the air-to-air Sparrow III for the Navy, the ground-to-air Hawk for the Army. Here, once again, Raytheon's "Excellence in Electronics" is contributing to the security of the nation.

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West Coast Industry



By Fred S. Hunter

Scope of the Marquardt Aircraft Co. facilities at Ogden, Utah, where it will produce the ramjet engines for the Boeing *Bomarc* missile for the Air Force, is illustrated by fact that the total investment may reach $30 million within five years. Cost of constructing and equipping the production plant on a 66-acre tract adjacent to the Ogden Municipal Airport—shared 50-50 by Marquardt and the Air Force—will come to $10 million.

The Air Force is footing the $13.5 million bill for the test facility on a 2100-acre site at Little Mountain. Marquardt hopes this test facility will be completed by 1959. Until then it will ship Ogden-produced engines to California to be tested at its Van Nuys facility. Marquardt employment in Ogden will reach 500 to 600 by the end of this year. Ultimately Utah employment is expected to total about 3000.

•

Instead of television, North American Aviation uses ejectable, recoverable, missile-borne film cameras for color motion picture coverage of the XSM-64 in Florida. NAA's Missile Development Division designed a six-camera system to provide a variety of engineering data and documentary coverage from "on board" for the Air Force. Two of these camera packages were devised to be ejected during flight and parachuted into the sea on completion of their photographic job. They are recovered through a radio signal transmitted by each floating unit and detectable by an airplane at a distance of about 35 miles. Direction also is indicated.

A "T-boat" receives directions from the airplane to guide it into the area where its own radio receiver can locate the units at a range of about 1½ miles. Location is further aided by use of a visible dye marker solution on the surface of the water.

•

Lockheed's Missile Systems Division is using a power brake—ordinarily used to bend heavy metal—to chop out tapered and twisted 10-inch aluminum spacers. They are achieving greater uniformity than by the hand method. Two dies are used is the process. The brake can be adjusted to produce spacers with a twist ranging from 17 to 22 degrees. The new process does in four hours what had previously taken 80 hours, and does it more precisely.

•

Apprenticeship program being started by Hughes Aircraft Co.'s Tucson plant this summer is aimed at turning out 32 trained machinists, 25 electronic technicians and 10 tool-and-die makers during first four years. Program is jointly administered by Hughes and the International Association of Machinists.

•

Delays in ground equipment caused postponement of the test firing of the *Atlas* . . . Researchers are showing more and more concern over the low level of support being given to basic research in comparison to the large amounts of money being poured into applied and developmental work . . . Convair Cove is the name given to the new 52-acre housing project for Convair technical personnel at Cocoa Beach, Fla.



"FEVER THERMOMETER"

for supersonic jets

In order to break sound barriers, jet engines must break some temperature barriers, too—which brings some real problems in material selection. Any thermostatic control in contact with the hot jet gases must withstand temperatures of 2000° without significant change in properties and characteristics.

Faced with this problem, one of the world's leading designers and manufacturers of aircraft components and systems has made Kennametal* a "Partner in Progress"—and has found an answer. For a vital part of the sensing element in a thermostat assembly, a small tube of Kentanium* is used. This material, one of a big family of unusual carbides developed by Kennametal, retains its responsiveness and reliability through the entire flaming range of operating temperatures.

Perhaps you have some new product in mind that is still on the drawing board for want of materials with the necessary properties to meet an unusual operating condition. If the need is for superior corrosion or erosion resistance, hardness, strength and stiffness, or resistance to elevated temperatures, the chances are that you can find the combination of properties you need in the Kennametal line. Just write, outlining your problem, to KENNAMETAL INC., Dept. MR, Latrobe, Pa.

*Kentanium and Kennametal are the trademarks of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum.

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As mach numbers advance, even fractional errors in inlet-air diffuser positioning reduce thrust tremendously.

Yet a fixed diffuser designed for optimum pressure at a given high mach number may be so inefficient at a lower mach number as to render it impossible for aircraft to reach design speed.

In the U.S.A.F.'s first supersonic bomber, Convair's B-58 Hustler, this problem was solved by Honeywell's variable inlet-air diffuser systems—the most accurate known. They are automatically controlled to the proper parameters to achieve maximum pressure recovery and mass air flow matched to engine requirements.

The Challenges to Come!

Variable inlet diffuser systems are just one of 114 research and development projects in which Honeywell Aero is engaged. These projects are in the basic areas of:

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And Honeywell's rapid growth assures you of early advancement. Engineering personnel at Honeywell Aero has tripled in the last 5 years, is still growing faster than the avionics industry average. Supervisory positions open quickly, are filled from within. The first-rate salary you start with at Honeywell is *just the start.*

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For more information concerning these opportunities, send your inquiry or résumé to: Bruce D. Wood, Technical Director, Dept. TA19E, Honeywell Aero, 1433 Stinson Boulevard, Minneapolis 13, Minn.

Honeywell
Aeronautical Division

Grand Central Makes Major Reorganization

Grand Central Rocket Co. has announced a major shifting in its project management organization. Willem Schaafsma, formerly director of engineering, is director of projects with a staff of five project managers. They are Angus Scott, D. H. Eccles, Rod Andrus, Wilbur Hartzell and Harold Bartel.

Scott is Schaafsma's assistant. Hartzell is senior engineer on the third stage of project *Vanguard.*

Republic to Study High-Temp Hydraulics

Republic Aviation Corp. has been awarded an Air Force contract for the study and design of a 1,000°F hydraulic system.

The contract includes mock-up of the system and associated components such as seals, pumps, material filters, electro-hydraulic valves, tube fittings, electrical wiring and test equipment. Republic also will study and develop high-temperature hydraulic fluids for this system.

ACF Forms Division For Advanced Products

ACF Industries, Inc., has formed a new Advanced Products Division which will specialize in pressed-metal items, special weldments, aircraft and missile components and other products. Division will contain personnel and facilities at ACF's St. Charles, Mo., and Milton, Pa.

Lockheed Gets X-7 Contract Extension

Lockheed Aircraft Corp. has received a $14.5 million Air Force contract for continuation of its X-7 ramjet engine test vehicle project. The new contract will extend the program into mid-1958.

The X-7 is used to check ramjets in supersonic runs at Holloman Air Development Center, N. Mex.

Westinghouse to Design, Build *Polaris* Systems

Westinghouse Electric Corp. will design and manufacture experimental seagoing handling and launching systems for Navy's *Polaris* ballistic missiles. Work will be done at the Sunnyvale, Calif., plant.

Program will involve a series of experimental systems leading ulti-

mately to a submarine launching for *Polaris*. Contract is with Bureau of Ordnance.

Richard N. Parkin, manager of the long-term missile launching and handling project at Sunnyvale and company coordinator, has recruited a staff of engineers and supporting technicians to work in a restricted area at the plant site.

Bristol Opens Three Branch Facilities

The Bristol Co. has recently opened two new branch factories and repair laboratories and relocated its Pittsburgh, Pa., district office.

Branches opened are at Houston and Los Angeles. The Pittsburgh office has moved to 2250 Noblestown Road and a new building housing sales and service staffs for industrial instruments for recording, controlling, and telemetering, electronic components, and pressure actuated aircraft devices.

Overtime Cut Reduces Ryan Payroll

Ryan Aeronautical Co. estimates payroll reduction resulting from the Department of Defense directive cutting out overtime will be about $120,000 a month.

The figure is based on an average four-week period of overtime work on the KC-135 and *Firebee* projects.

Sperry Rand Builds Florida Facility

Sperry Rand Corp. is building a $2 million facility at Clearwater, Fla., for development of advanced radar instrumentation. First building to go up will be a 75,000-sq.-ft. laboratory for Sperry's newly organized Electronics Division. Operations are scheduled to begin late this year.

Gyroscope Assembled Under Microscope

Microscope aids technicians at AC Spark Plug Division of General Motors assemble parts of a gyroscope for use in missiles. Work is done under plastic shields in special air-conditioned rooms to make certain gyro is free of dust.

Chance Vought Files Debenture Issue

Chance Vought Aircraft, Inc., has filed a Security and Exchange Commission registration statement covering proposed issue of $12.5 million of convertible subordinated debentures. This

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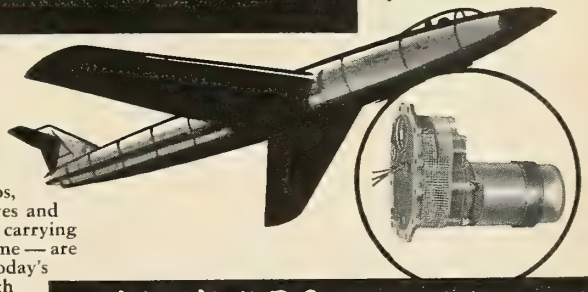
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marks the first public financing of the firm since it became independent of United Aircraft in 1954.

Funds will be used to reduce bank loans incurred to finance increased inventories and accounts receivable. Debentures will be convertible into common stock through July 1, 1967. Harriman & Ripley & Co. heads the underwriting group.

Litton Sales up 90% For 1st Nine Months

Litton Industries realized sales of $20,372,000 for the first nine months of the current fiscal year, a 90% increase or the comparable period last year, according to Charles B. Thornton, president.

Profits of $1,154,236 for the period which ended April 30, were an 85% increase over last year. Earnings per share were $1.10 on the $1,-154,236 outstanding. Backlog April 30 was $44 million, a new high.

DFI Completes Test Program for *Redstone*

Designers for Industry, Inc., has completed four pieces of testing equipment for the *Redstone* rocket missile under sub-contract to the Chrysler Corp. Equipment tests guidance mechanism and other components of missile during production and just prior to launching, DFI officials said.

NAA Gets Subscontract For *Titan* Equipment

North American Aviation's Los Angeles Division has received a subcontract from The Martin Co. to build ground equipment for the *Titan* missile, Work will begin immediately on the transtainer units used to transport the big missile on the ground.

Oregon Firm Casting Titanium, Zirconium

Oregon Metallurgical Corp. is producing titanium and zirconium castings in a 100-lb. capacity consumable electrode furnace.

Since the metals in the liquid state react with every known element except

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argon and helium, the mold itself must be contained in the melting furnace. Water cooled copper and graphite molds have been successfully used and castings of 125,000 psi tensile strength produced.

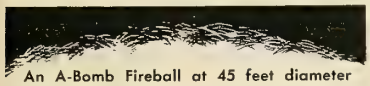
Castings will soon be available in pure titanium, zirconium or alloyed with aluminum, vanadium, tin, chromium, manganese, molybdenum and other alloys.

Coleman Increases Board Membership

Coleman Engineering Co. Board of Directors has been increased from seven to nine members. New seats are filled by E. A. Gardner, vice president and general manager of the company, and James Beattie, president of Photographic Products, Inc., Anaheim, Calif., a Coleman subsidiary.

ARDC Lets $81,000 Contract For Plan

Air Research and Development Command has awarded a contract to Porter, Urquhart, McCreary and O'Brien of Los Angeles to prepare a master plan for its missile training center at Camp Cooke, Calif.



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Openings as of July 1

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A partial listing follows. Information on many more positions may be obtained by contacting Robert Burchell at the address below.

MISSILE PROJECT ENGINEER
Coordinate project analysis, planning and controls including determination of project requirements and commitments in missile field.

ELECTRONIC SYSTEMS ENGINEER (Field Service)
Liaison with associate contractors and government agencies on inertial guidance system project. Must be thoroughly familiar with matters relating to digital and analog computers, power supplies, environmental conditions, housing and test facilities and test equipment.

FIELD EVALUATION ENGINEER
Perform overall planning functions for field evaluation of missile guidance systems. Direct activities in scheduling the field operations. Liaison with field test site agencies and formulating overall operating procedures at test site on missile project.

MECHANICAL DESIGN ENGINEER
Perform mechanical design of airborne instrumentation and transducers required for field evaluation of missile guidance systems. Responsible for packaging and mounting equipments.

FUNCTIONAL ENGINEERS—MISSILE SYSTEMS
Develop inertial guidance systems including gyro, accelerometers, integrators, servo systems and computers. Analyze functional problems arising during development and evaluation of said system.

OPERATIONAL EVALUATION ENGINEER
Perform engineering studies and analysis of techniques for evaluating performance of missile guidance systems and its components including gyros, accelerometers, digital computers.

PLATFORM ENGINEER
Conduct investigation of a theoretical nature relating to gyros or inertial platforms including design of closed loop control equipment pertaining to the above.

GYRO DEVELOPMENT ENGINEER
Develop precision gyro systems including mechanical problems such as lubrication, temperature controls, hydrostatics and vibration and electronic work on accelerometers, amplifiers, torquing circuits and electrical pickups.

OPERATIONAL ANALYSIS ENGINEER
Development work on evaluation of inertial guidance systems including in-plant and flight analysis of gyro systems. Development of measuring devices for precise determination of in-flight velocity, acceleration, altitude and position information.

RELIABILITY ENGINEER
Develop methods for evaluation of accuracy, reliability and operational suitability of missile guidance systems.

SYSTEMS EVALUATION (MISSILE GUIDANCE)
Perform functional engineering studies and design of inertial guidance systems, determine system and component requirements and performance, conduct system and component dynamic studies and simulation, perform error analysis.

PROJECT ENGINEER—PRODUCTION TEST EQUIPMENT
Administer and technically direct the program of design, development and manufacture of test equipment for production use in the manufacture, inspection, test and reliability control of highly complex electronic, electro-mechanical and gyroscopic equipment required for missile application.

GROUND EQUIPMENT ENGINEER
High degree of technical and administrative responsibility on complex projects involving the design and development of production test and field test equipment for gyroscopic systems and digital computers.

PROJECT ENGINEER—AIRBORNE EQUIPMENT
Guide and assist engineers in technical problems in field of electrical and electronic design, servo systems, missile guidance systems. Responsible for major product improvement program and test programs. Provide technical liaison with quality control. Heavy servo background desired.

ENVIRONMENTAL ENGINEER
To plan, conduct and report upon development studies of finishes, materials and processes, which will be incorporated into the design of electromechanical and electronic components and systems.

OPERATIONAL ANALYSIS ENGINEER
To plan, conduct and report upon environmental tests of electromechanical and electronic systems. Must be capable of redesigning components or systems to correct any deficiencies encountered during the evaluation program in the computer, servo systems and missile field.

QUALITY CONTROL ENGINEER
Require experience in gyroscopic trouble shooting. Design knowledge of stable elements and some background regarding reliability and failure association for complex guidance systems to be used in missile field. Must have complete knowledge of statistical methods.

GROUND EQUIPMENT ENGINEER
Plans and performs engineering studies, basic electrical and mechanical design, development and evaluation of production test and field test equipment where specific objectives and general requirements are known. Must be familiar with electromechanical instrumentation.

Clip the job (or jobs) you're interested in and mail, with your confidential resume. No reference contact without your permission. You'll receive a prompt reply, and your copy of "Your Engineering Career with Arma," full of detailed information about this company.

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industry briefs

BARNEY CONTROLS INC. will integrate marketing activities of all divisions and product lines into a new marketing department headed by Edward A. Johnson as vice president for marketing.

OLIN MATHIESON CHEMICAL CORP., Aluminum Division has opened its first Olin Aluminum office in the U. S. at Atlanta. Office will be used as sales headquarters for Southern states.

AMERICAN ELECTRONICS, INC., American Laboratories Division, has broken ground for a new environmental test laboratory at Fullerton, Calif. Completion is slated for August.

DARCO INDUSTRIES, INC., has acquired controlling interest in the Demo-Haines Tool Corp. Darco will produce 9½-lb. Demo electric hammer at El Segundo. Company is designer and manufacturer of aircraft and missiles parts and equipment.

BELOCK INSTRUMENT CORP. has broken ground for its Engineering Center at College Point, Queens, N. Y. R&D center will contain 30,000 sq. ft. for engineering facilities.

WALDALE RESEARCH CO., INC., has moved from Las Vegas to El Monte, Calif. Firm is manufacturing electric and high temperature strain measuring devices.

INDUCTION MOTORS CORP. reports consolidated net sales of $2,489,945 for 1956. Figure includes six months operations of the company's new PSP Engineering Division. Net income for year was $127,364 on 141,179 shares outstanding.

MARQUARDT AIRCRAFT CO., authorized a 2-for-1 stock split by payment of a 100% stock dividend July 1.

NORTH AMERICAN AVIATION'S Autonetics Division has set up an eastern Branch office in Washington, D. C. at Cafritz Bldg., 1625 I St. N.W. under Norman P. Hays, manager.

MARQUARDT AIRCRAFT CO. reports net earnings of $605,236 in 1956, an increase of 80% over 1955. Sales reached an all-time high of $23,110,441, up 104% over previous year. Backlog on February 24 stood at $55 million, including a number of USAF contracts for production of ramjet engines for Boeing *Bomarcs*.

ATLANTIC RESEARCH CORP. of Alexandria, Va. has acquired U.S. Flare Corp. & Associates of Pacoima and Saugus, Calif. and will operate latter under the same name as an affiliate. USF specializes in rocket ignition systems, missile tracking equipment, pyrotechnics and high-explosive ordnance items. Acquisition gives the combined organization a current annual volume exceeding $4 million and a staff of 325.

TRANSFER by North American Aviation of its missile test facility operations from Patrick AFB to Cape Canaveral Industries Area has been completed.

THE SIEGLER CORP., Electronics Division, has been awarded a rapid tax write-for missile systems facilities in the amount of $130,000 at 40% allowance.

SYLVANIA ELECTRIC PRODUCTS, INC. has started construction of a multi-million dollar, 100,000 sq. ft. R&D facility at Amherst, N. Y. for its Electronic Systems Division. Target for completion is February 1958.

METALS & CONTROLS CORP., will open a west coast design engineering facility this month. William Jones will head the Los Angeles laboratory and office staff as project engineer.

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missile literature

WIRE SAMPLE CARD. Samples of high temperature insulations are offered on pocket-size sample cards. Typical samples are Teflon, silicone insulated magnet wires, lead wires, sleeving, tubing, shielded and jacketed cables. American Super-Temperature Wires, Inc.

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DECIMAL-BINARY TABLES. Series of tables simplify conversion from decimal to binary numbers, or vice versa. Tables are compact, instructions concise. Measure 3½" x 8½". Barnes Engineering Co.

Circle No. 101 on Subscriber Service Card.

WAVEGUIDE PRESSURE WINDOWS. Brochure describes waveguide pressure windows, gives uses. Performance curves, outline dimensions, drawings, complete data given. Microwave Associates, Inc.

Circle No. 102 on Subscriber Service Card.

INSTRUMENT TRANSLATOR. Bulletin describes instrument translator which operates from ac or dc power source, integrates ac or dc sensors with ac or dc control mechanisms. Crescent Engineering & Research Co.

Circle No. 103 on Subscriber Service Card.

POWER RECTIFIERS. Set of 4 data sheets gives engineering information on full wave silicon rectifiers including electrical ratings, characteristic curves and dimensions. Sarkes Tarzien, Inc.

Circle No. 104 on Subscriber Service Card.

EPOXY ADHESIVES. Chart gives properties and other material information on epoxy adhesives for use in tooling, electrical, assembly and manufacturing of missiles. Furane Plastics, Inc.

Circle No. 105 on Subscriber Service Card.

TRIGULATOR. Illustrated 12-page brochure gives details on instrument which is said to save 90% of time spent in many mathematical problems. Complete data, sample problems given. Fitch Instruments, Inc.

Circle No. 106 on Subscriber Service Card.

MAGSLIPS. 60-page book gives designers all they need to know about magslips and synchros. Illustrated with photos, graphs, and circuit diagrams. History and development of magslips presented, has comprehensive subject index. Muirhead Instruments, Inc.

Circle No. 107 on Subscriber Service Card.

HAZARD FINDER. Safety check list in 8-page illustrated folder is guide to evaluation of hazard potential in plant or laboratory where flammable gases, vapors, dusts, liquids and other materials are handled. Crouse Hinds Co.

Circle No. 108 on Subscriber Service Card.

PHASE VOLTAGE CONVERTER. Data sheet gives all details of a rotating phase voltage converter suitable for testing sound track equipment. Kato Engineering Co.

Circle No. 109 on Subscriber Service Card.

SELF LOCKING NUTS. 36-page illustrated brochure gives weight, size temperature and material for miniaturized self-locking nuts for use in electronic units and missile equipment. Elastic Stop Nut Corp. of America.

Circle No. 110 on Subscriber Service Card.

TIMING MOTORS. Bulletin sheet contains details on three basic dc timing motors along with detailed explanation of construction and operation. A. W. Haydon Co.

Circle No. 111 on Subscriber Service Card.

SOLENOIDS. Basic types of solenoids for aircraft and missile applications contained in 4-page catalog. Tables provide data for both continuous and intermittent duty. Complete specifications of five types given. W. L. McMichael, Inc.

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CORROSION TESTER. Illustrated 16-page brochure describes system for determining rates of corrosion. Instrument is available in two models for line or battery power sources. Labline, Inc.

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FLEXIBLE HOSE. 8-page booklet describes flexible hose and ducts for variety of uses. Illustrations, data tables, applications, advantages listed. Flexaust Co.

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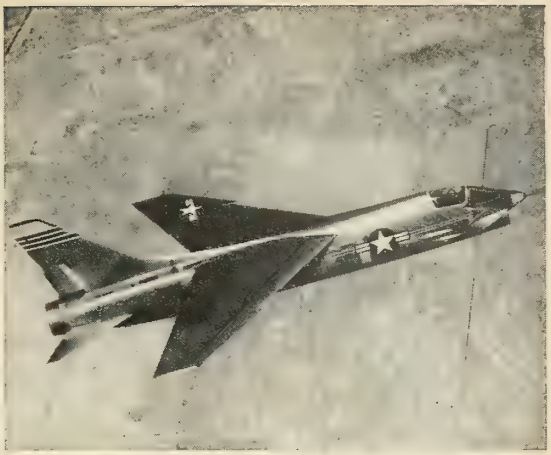


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Engineers at the Hamilton Standard Division of United Aircraft selected Bristol's capsular pressure sensing elements for the fuel control systems soon to go into planes like the Navy F8U Crusader, above.

For Bristol has built up a backlog of 67 years experience in manufacturing pressure-sensing elements for use in our own Bristol instruments under the most diverse operating conditions.

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(Stock Capsules)

Characteristic	Range Min.	Max.
Outer diameter (in.)	1 5/16	2 11/32
Effective area (square in.)	0.40	1.67
Travel (in./psi)	0.0004	0.015
Pressure span (psi)		
• Expansion	2	100
• Compression	2	100
Deviation from linearity (max %)	1/4	1
Hysteresis effect (max %)	1/4	1/4
Allowable overpressure (max % to maintain linearity)	20	20
Temperature range (normal)	—65 to 300F	—65 to 300F
Temperature for 2% travel change	550F	550F
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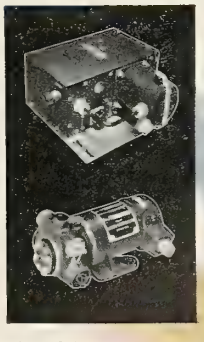
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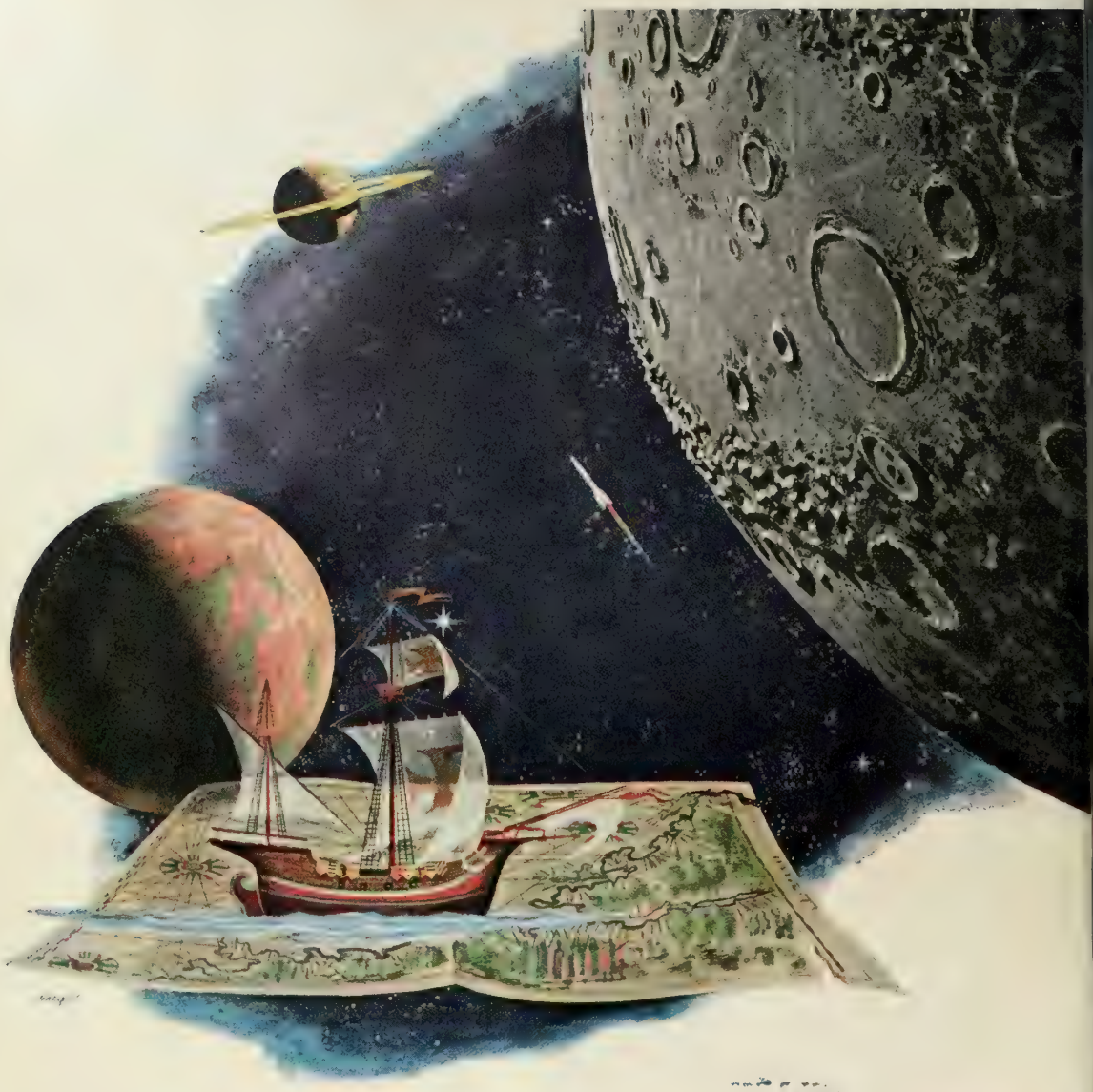
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DOING JOBS EVERY DAY THAT METALS ALONE CAN'T DO



Convair C-131B Flying Electronic Test Bed with Two Pod-Mounted "Mars" APU's

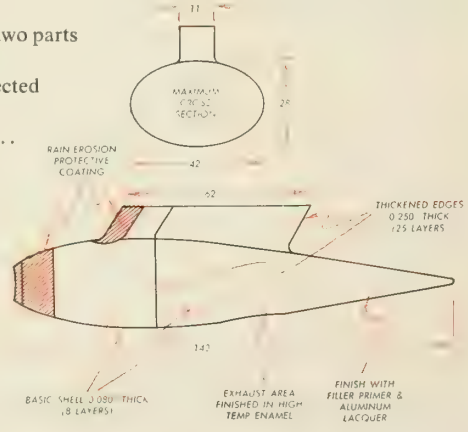
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NORTHROP NEW BUILDING NEAR FINISH

Full Occupancy In Late Summer

(HAWTHORNE, CALIF.) Partially occupied now, the new Northrop Engineering and Science Center at Hawthorne, latest step in a gigantic modernization and expansion program, is almost completed. Engineers and scientists of the Northrop Division of Northrop Aircraft, Inc., are ready for the big move into this beautiful, multi-million-dollar, glass and steel six-story building in late summer.



Architect's rendering of the Science Center is pictured above. Every convenience and facility will be provided for human well-being and comfort, in keeping with Northrop's theory that an engineer can do his work most efficiently in pleasant surroundings. Northrop has long maintained that an airplane or missile is only as good as the engineers who design it.

When fully completed, Northrop will have one of the most advanced test and experimental facilities in the entire aircraft industry. The Engineering and Science Center is the nucleus of this extensive development program. A four-unit Test Complex, which includes a Test Building, a high-performance, sub-sonic Wind Tunnel, a jet engine Test Cell, and an Environmental Test Laboratory, is now fully operative. Here, in these dramatic, modern buildings, Northrop engineers and scientists will continue with their never-ending study of airborne guidance, nuclear energy, the thermal barrier, aerodynamics, human engineering and other areas of missile and jet aircraft research.



MISSILE ENGINEERS

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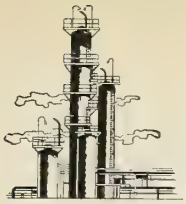
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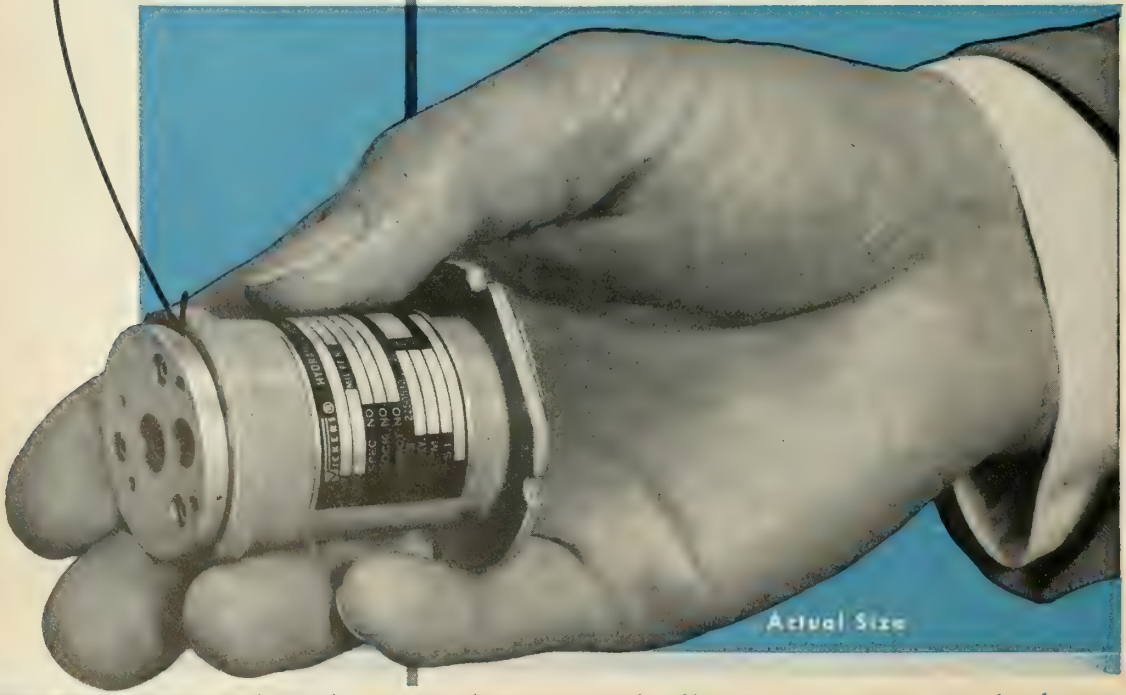
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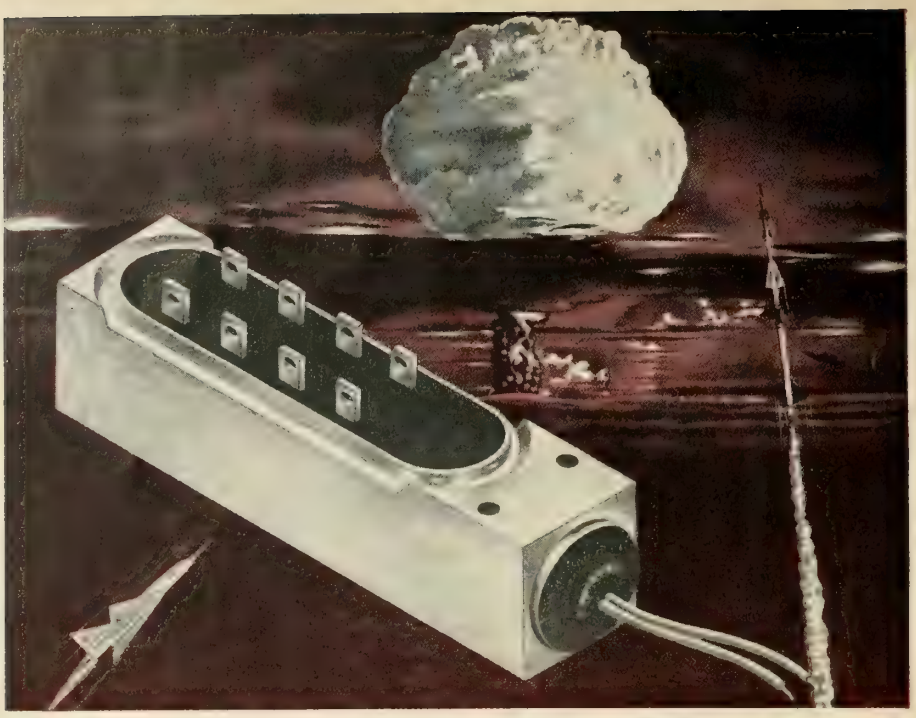
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editorial

Space Flight Without Red Tape

America's first space flight attempt is to be an Air Force venture using Army hardware and Navy methods. Industry and private scientists will put the vehicle together and instrument it. First of all, this is indicative of the fact that a unified group of our foremost research establishments must be coordinated into one central agency for successful pursuit of the astronautics challenge. Project *Far Side* is only the beginning. In scope, however, the project is more sophisticated than Project *Vanguard*. And in terms of politics it is far more interesting.

Space flight is not a glamorous little game that can be played by anyone just for glamor's sake. The Defense Department cannot arbitrarily choose any single individual or any single one of the services to supervise this country's overall aims to conquer the black yonder of space. The significance of such programs is too important in terms of expenditures and prestige. American industry certainly would not compliment the Defense Department if DOD should fail to make a thorough canvass of possible unification of efforts, talents and funds.

The Air Force Office of Scientific Research is to be commended for undertaking Project *Far Side*. Obviously, AFOSR recognizes the necessity for coordination and unification as essential ingredients for the project's fulfillment. Most important, however, is that the industry and military enthusiasts behind Project *Far Side* are aiming to penetrate outer space without political red tape—by picking the best methods and hardware available without caring which Service made them.

Project *Far Side* is simple. It is worthwhile. It is indicative of what a coordinated military and industrial effort can and will achieve with a minimum of expenditures and complexities. It uses off-the-shelf military hardware. No basic component for the rocket vehicle has to be redesigned, nor re-contracted. No expensive preflight tests are required. It does not cut into existing programs. When the first *Far Side* rocket is fired some time next month, the vehicle will be "live."

Far Side represents thousands of dollars rather than millions. Here we are working with simple, solid-propellant rockets instead of a combination of intricate liquid systems requiring five, six or more propellants or combinations of propellants.

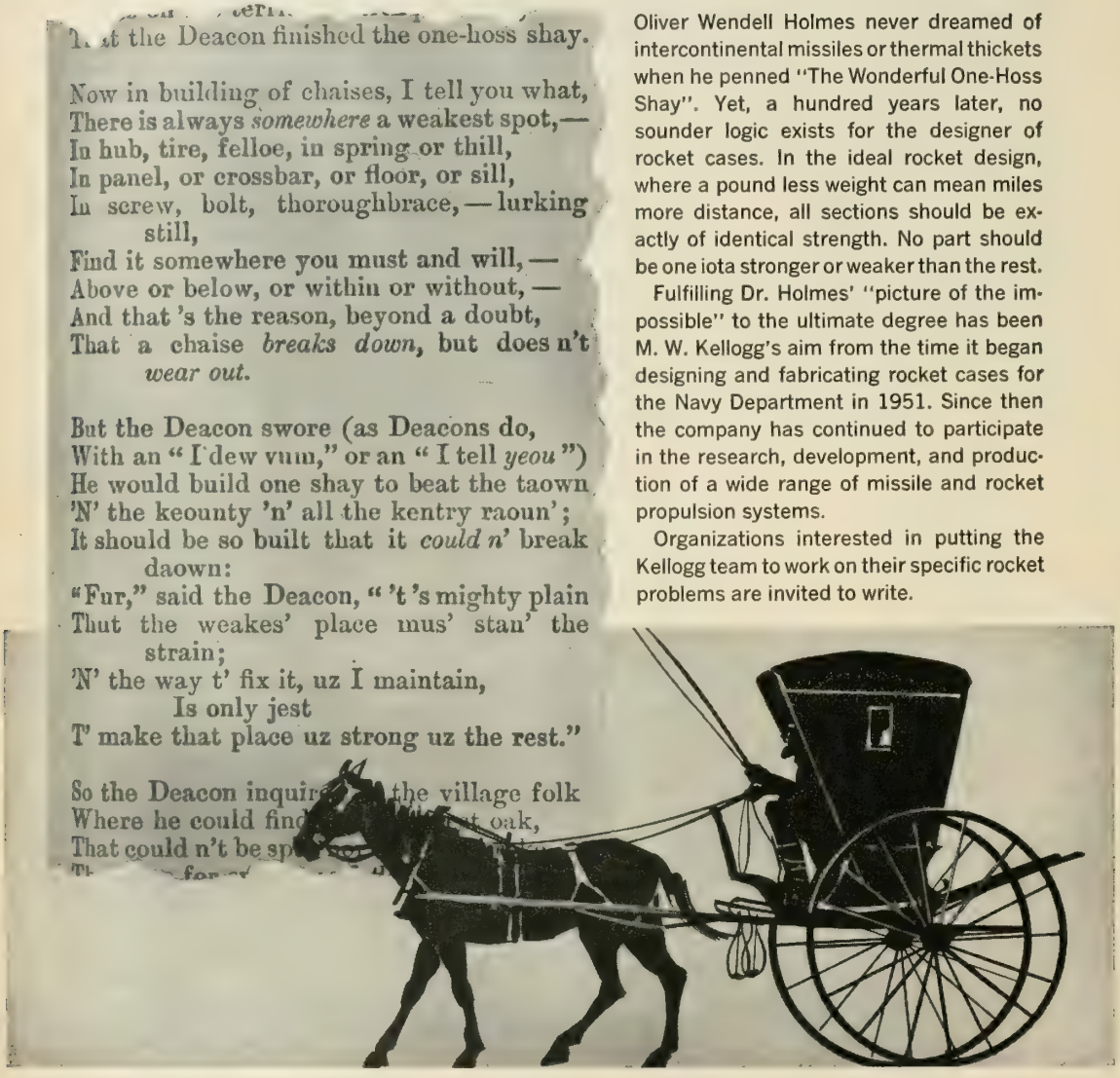
Project *Far Side* makes the *Vanguard* project look like a hydra-headed monster. This also applies to such timid matters as releasing information to the public. The taxpayer, who is immensely intrigued by the idea that we are about to challenge outer space, does not understand why he cannot get the information on Project *Vanguard*.

But he does not know that every single word to the public must be cleared by all of these: the prime contractor; Naval Research Laboratory's Technical Information Office; the Chief of Naval Research; Office of the Chief of Naval Information; Office of Public Information of Department of Defense (including representatives of Army, Navy, Air Force and DOD); the Central Intelligence Agency; State Department; National Science Foundation; and the National Academy of Sciences (U.S. Committee for the IGY). This web of red tape on information is the big talk and the top sarcasm of the industry.

It is good that the Air Force is set on proving that we can spend less of the taxpayer's money and cut down the red tape on this country's first space flight project. And that there is no politics involved. It will pay. The public will expect the Air Force Office of Scientific Research to continue to pursue the space flight challenge in the future . . .

ERIK BERGAUST

Rocket Logic in Retrospect



t the Deacon finished the one-hoss shay.

Now in building of chaises, I tell you what,
There is always *somewhere* a weakest spot,—
In hub, tire, felloe, in spring or thill,
In panel, or crossbar, or floor, or sill,
In screw, bolt, thoroughbrace, — lurking still,
Find it somewhere you must and will, —
Above or below, or within or without, —
And that 's the reason, beyond a doubt,
That a chaise *breaks down*, but does n't *wear out*.

But the Deacon swore (as Deacons do,
With an " I dew vum," or an " I tell *yeou* ")
He would build one shay to beat the taown
'N' the keounty 'n' all the kentry raoun';
It should be so built that it *could n'* break daown:
"Fur," said the Deacon, " 't 's mighty plain
Thut the weakes' place mus' stan' the strain;
'N' the way t' fix it, uz I maintain,
Is only jest
T' make that place uz strong uz the rest."

So the Deacon inquir[illegible] the village folk
Where he could find[illegible] oak,
That could n't be sp[illegible]

Oliver Wendell Holmes never dreamed of intercontinental missiles or thermal thickets when he penned "The Wonderful One-Hoss Shay". Yet, a hundred years later, no sounder logic exists for the designer of rocket cases. In the ideal rocket design, where a pound less weight can mean miles more distance, all sections should be exactly of identical strength. No part should be one iota stronger or weaker than the rest.

Fulfilling Dr. Holmes' "picture of the impossible" to the ultimate degree has been M. W. Kellogg's aim from the time it began designing and fabricating rocket cases for the Navy Department in 1951. Since then the company has continued to participate in the research, development, and production of a wide range of missile and rocket propulsion systems.

Organizations interested in putting the Kellogg team to work on their specific rocket problems are invited to write.

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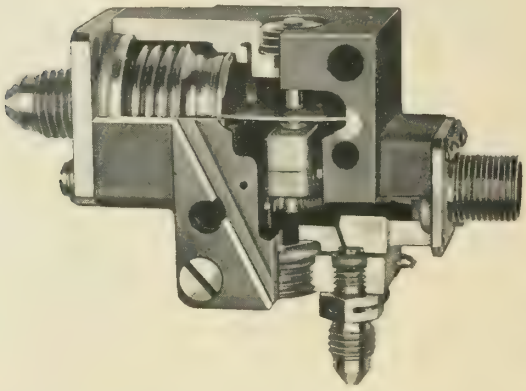
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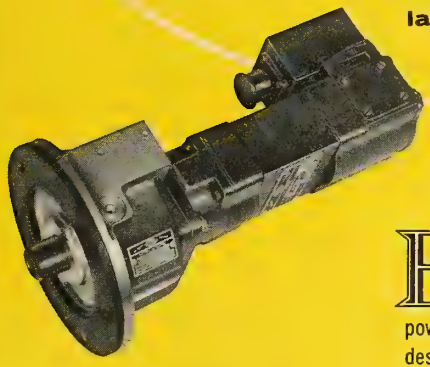
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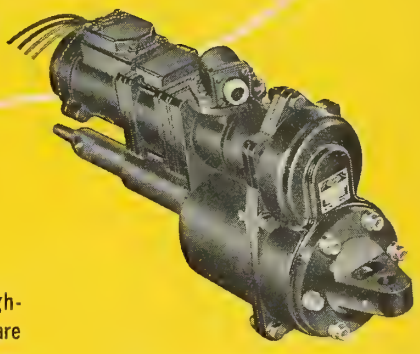
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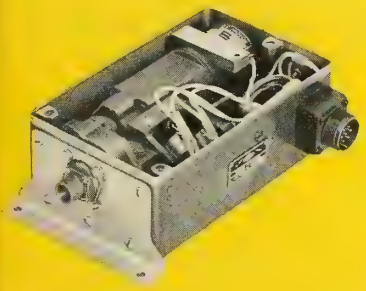


Type: D-925 Rotary Actuator for Missile Fin. **Output:** 400 inch-pounds @ 64 RPM, 24 volts, 27 amps. **Duty Cycle:** 1 minute on, 10 minutes off; **Gear Reduction:** 135 to 1 in 2.25" length; **Weight:** 6.75 lbs. **Meets Mil. Specs.:** MIL-A-8064 for actuators, MIL-M-8609 for motors.

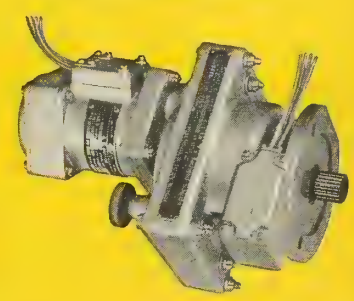


Type: D-818 Leading Edge Flap Actuator; **Weight:** 20.5 lbs. **Normal Operating Load:** 6,000 lbs.; **Maximum Operating Load:** 12,000 lbs. **Ultimate Static Load:** 24,000 lbs.; **Stroke:** 3.15"; **Rate of Travel:** .33" per second; **Amperes:** 3 amps at 480 cycles on 200 volts at the 6,000 lbs. load. **Meets Mil. Specs.:** MIL-A-8064 for actuators, MIL-M-7969A for motors.

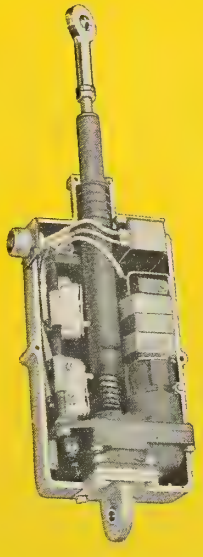
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Type: D-892 Power Package; **Size:** 7⅛" x 4¾₆" x 2¾". **Output:** 28 volts D.C., 1390 RPM at take-off shaft, 18 inch-oz. torque. **Weight:** 3⅜ lbs.; Operative in ambient temperatures to 250° F. **Meets Military Specifications:** MIL-A-8064 for actuators, MIL-M-8609 for motors.



Type: D-868 Rotary Actuator; **Weight:** 9⅞ lbs. **Power:** 200 volt, 400 cycle, 3-phase motor. **Ambient Temperature Range:** —65°F. to +400°F.; **Shaft Torque Limit:** Adjustable. **Load:** 1,650 inch-lbs. maximum to approx. 2 RPM on 1.5 amps. **Meets Military Specifications:** MIL-E-7894 and MIL-A-8064.



Type: D-607 Transport Door Actuator; **Weight:** 4.5 lbs. **Stroke:** 6.25"; **Operating Load:** 450 lbs.; **Ultimate Static Load:** 7150 lbs. tension; **Speed of Stroke:** under 450 lb. load—0.3" per second. **Size of Power Section:** 2¼" x 4½" x 8⅝". **Meets Mil. Specs.:** MIL-A-8064 for actuators, MIL-M-8609 for motors.



Type: D-822 Trailing Edge Flap Rotary Actuator; **Weight:** 35 lbs. **Normal Operating Load:** 26,000 inch-lbs. **Maximum Operating Load:** 52,000 inch-lbs. **Ultimate Static Load:** 75,000 inch-lbs.; **Travel:** 45 degrees at .625 RPM; **Amperes:** 4 amps at 26,000 inch-lbs. at 480 cycles on 200 volts. **Frequency Range:** 380 to 420 cycles. **Meets Mil. Specs.:** MIL-A-8064 for actuators, MIL-M-7969A.

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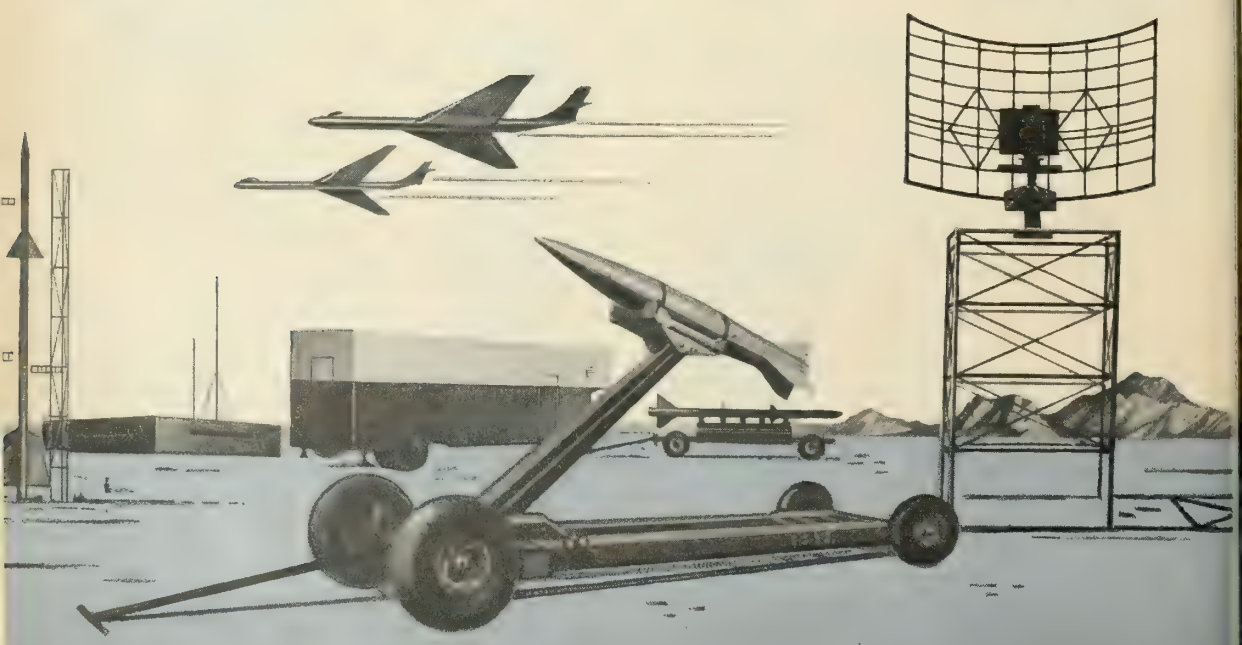
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LIQUID PROPELLANTS & EXOTIC FUELS

cover picture:



Lacrosse, *Army's lightweight tactical missile now in production, rests on its launching rack aboard an Army truck. The ground-to-ground weapon is powered by a Thiokol solid propellant rocket motor and will be used to supplement air or artillery attack on enemy strong points in the field.* Lacrosse *is Army's most sophisticated missile and utilizes a command guidance system in conjunction with a forward observer.* *See articles on pages 112 & 121.*

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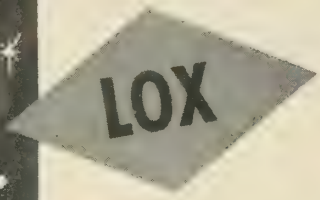
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letters

Praise for m r First Special Issue

To the Editor:

Better and better! Suggestion: The coverage on missiles in the July issue was good. How about a future feature covering the available research missiles, such as Aerobee-Hi, Dan, X-17, etc. This should be as complete as possible, including size, weight, c.g., cost, etc. It would be even better if the page layout allowed margin for cutting out, for inclusion in notebooks.

Second Suggestion: A continued series on missile components; for example, solenoid valves, turbine pumps, telemetry packages, gyros, and so on. Basic theme: a system can be no better than its components.

R. P. Haviland
General Electric Co.
3198 Chestnut Street
Philadelphia 4, Pennsylvania

Thank you. A missile component issue is coming up.—Ed.

To the Editor:

Congratulations on the color spread entitled "To Probe Tomorrow" in last month's edition of MISSILES AND ROCKETS magazine. This functional use of color vividly portrays the research tools in GE's Aerosciences Laboratory.

Incidentally, I believe your readers should know that the Aerosciences Laboratory was initially established to provide research for the development of Air Force Ballistic Missiles under the direction of the Air Force Ballistic Missile Division, commanded by Major General B. A. Schriever, in Inglewood, Calif.

J. C. Hoffman
Manager-Product Information
GE MOSD
3198 Chestnut Street
Philadelphia 4, Pennsylvania

To the Editor:

Is it possible to obtain 25 copies of Dr. Wernher von Braun's article "Space Travel and Our Technological Revolution" as published in your First Annual Engineering Progress issue?

J. M. Schneider
The Cincinnati Shaper Co.
Hopple, Garrard, and Elam Sts.
Cincinnati 25, Ohio.

Reprints are in the mail.—Ed.

To the Editor:

Your July m/r guest editorial, "Science and Common Sense" could not have been more appropriate for your engineering progress issue. Also appropriately, it was written by the world's greatest exponent of the subject "science and common sense"—Dr. Theodore von Karman.



Checking m/r galley proofs: Dr. Theodore von Karman, right, with m/r's exec. editor.

Only too often the work of the theoretical physicist is not implemented by the engineer due to the lack of technological intuition on the part of the business executive who authorizes and directs the activities of the engineer.

Those who profess to have management expertise have singularly failed to provide a program of technical enlightenment for the business executive. It is typical of Dr. von Karman that he would have the wisdom and common sense to discuss this problem.

I have the temerity to suggest that you run a series of articles on the subject.

Andrew G. Haley
Haley, Wollenberg & Kenehan
1735 DeSales Street N.W.
Washington 6, D.C.

To the Editor:

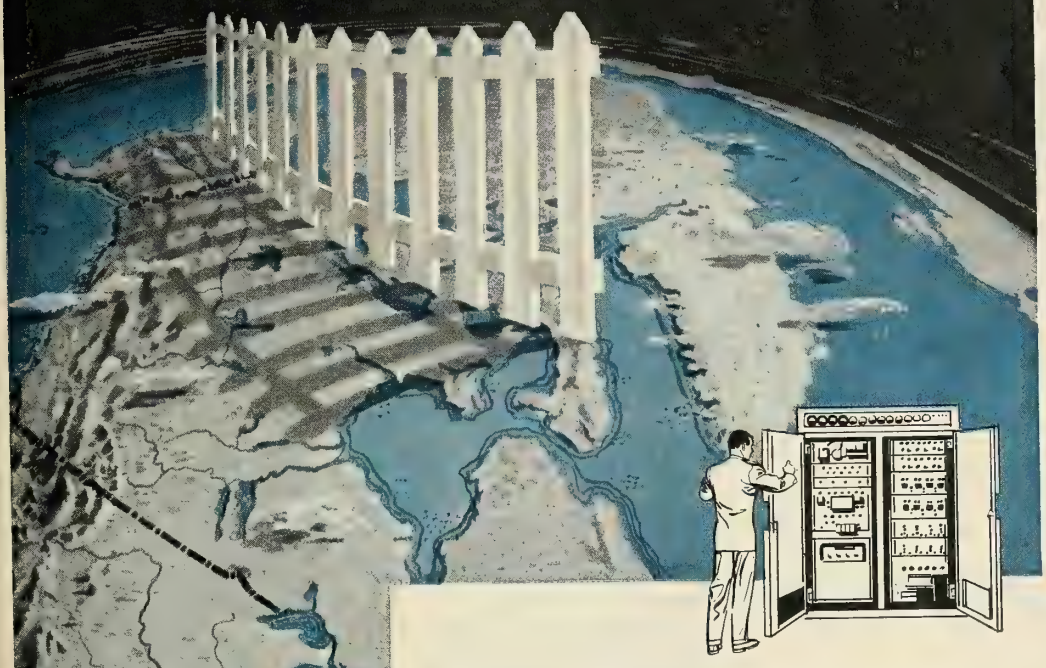
I am writing to tell you of my appreciation of m/r's recent coverage of Army missile activities and particularly to the activities of the Corps of Engineers in support of various missile programs.

The article "Missile Progress by the Corps of Engineers" by Major General



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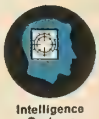

Solid State Physics

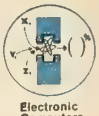

Missile Systems and Components

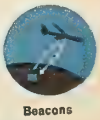

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Circle No. 40 on Subscriber Service Card.

David H. Tulley, and the accompanying editorial box, in the July issue will do much to give industry and the public a better understanding of the Army Engineers' part in the missile program.

E. C. Itschner
Major General, U.S. Army
Chief of Engineers
Washington 25, D.C.

To the Editor:

Since m/r first appeared last year many of us here at Maxson have watched it carefully.

The July issue contains a terrific amount of information, particularly the First Annual Guided Missile Encyclopedia, beginning on page 123. This round up is the best job along these lines that we have yet seen. We wonder if reprints of this section are available. If so, we would appreciate having ten copies for distribution to our key personnel and engineering staff.

Keep up the good work.

S. H. Goldstein,
The W. L. Maxson Corp.,
Contracts Division
475 Tenth Ave.
New York 18, N. Y.

Thank you. The reprints are in the mail.—Ed.

To the Editor:

I was very pleasantly surprised to find in your July 1957 issue the "Guided Missile Encyclopedia."

I am an instructor in the U.S. Army Ordnance School and have spent countless hours trying to compile something similar for use in my instruction.

Is it possible to get about five reprints? We can sure use them.

Cutt R. Wild
Lt., Ord. Corps
U.S. Army Ord. Sch.
Box 195, APG, Md.

In the mail.—Ed.

To the Editor:

I have just returned from a trip to many of the Air Force Research and Development Command centers located throughout the nation. It was interesting to me to note the many copies of MISSILES AND ROCKETS that I saw on desks while visiting scientists at these various development centers. I think this is more than adequate proof of the job that m/r has done in covering this most important field . . .

Joseph C. Groth, Jr.
Executive Assistant to the President
Winzen Research Inc.
8401 Lyndale Avenue South
Minneapolis 20, Minn.

To the Editor:

I congratulate you on your excellent magazine. As a laboratory technician interested, but not yet connected with rocket propulsion in England, I find m/r of great interest and value. I also very much appreciate the advertising sections of this periodical, which presents in one issue more interesting information on missile components and developments than in several months of British aeronautical magazines.

This is, of course, due to the very high level of security on guided missiles in this country. Consequently British lay-

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men have had to look to other quarters for their literature. Apart from the journal of the British Interplanetary Society very little information is available on current missile developments in this country. However, you have stepped in and very nicely filled the gap. I wish you every continued success.

Raymond A. Harraway
38 Waldeck Street
Reading, Berkshire,
England

Publication of Considerable Impact

To the Editor:

I would like to take this opportunity to compliment you on your publication. As an organization with eleven plants and laboratories actively engaged in missile work, we have followed the magazine from its very beginning. It is quite apparent that it is a publication of considerable impact . . . and might well have even more significant importance in the future . . .

The check list of special selections which you published this year is, I think, a very fine idea and one which should be repeated at intervals.

Alan Craigue
American Machine & Foundry Co.
1101 North Royal Street,
Alexandria, Va.

Pictures Suitable for Framing

To the Editor:

Minneapolis-Honeywell Regulator Company, Aeronautical Division, has recently completed construction of a new plant here in St. Petersburg. This plant has been set up for research and development on inertial guidance controls.

Because of our field of interest, we are most anxious to obtain pictures of missiles to place on the walls of various departments. We don't know where to go for pictures of this type and are wondering if perhaps you could help us. Any information as to possible sources would be most appreciated.

Mrs. Virginia Batchelor, Librarian
Minneapolis-Honeywell
Regulator Co.
St. Petersburg, Florida

Most companies in the missile business probably will be happy to provide you with glossy photos etc. Write to their Public Relations departments. Also, try General Astronautics Corp., P. O. Box 26, Oyster Bay, N. Y.—Ed.

Wants NACA Technical Note

To the Editor:

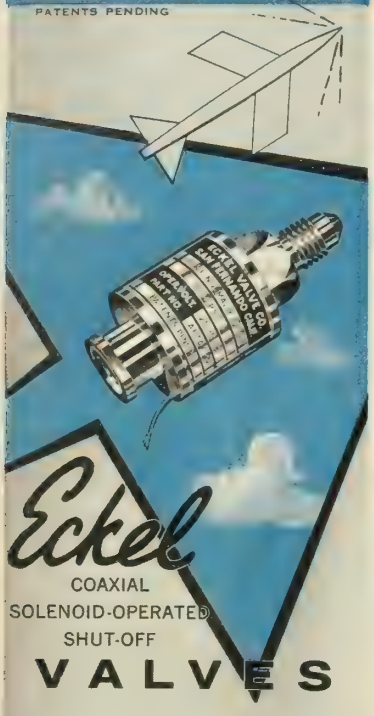
We are subscribers to your publication and we read in the June issue, page 100, an article regarding the new method of manufacturing by the NACA.

Could you be so kind and ask this Committee to send us their technical note No. 3827 referred to in the mentioned article; we do not know the address of the NACA.

Jean Gallay
Usines Jean Gallay S.A.
Chemin Frank Thomas
Geneve, Switzerland

Address of the National Advisory Committee for Aeronautics (NACA) is 1512 H St. N.W., Washington 25, D.C. —Ed.


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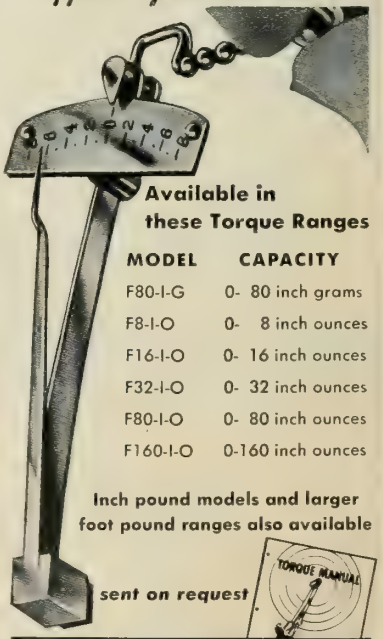

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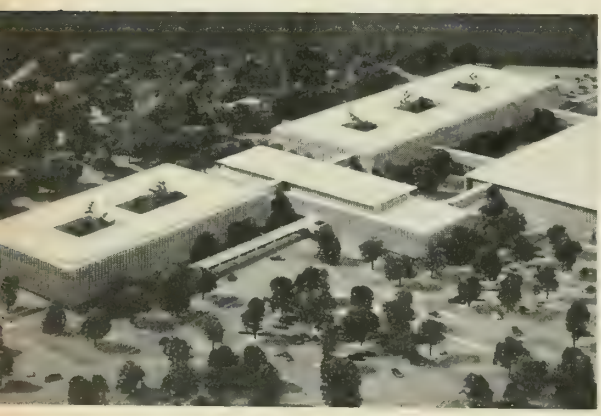
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Dr. Dorothy M. Simon, Technical Assistant to the President of Avco Research and Advanced Development Division, addresses a colloquium of the Advisory Group for Aeronautical Research and Development (NATO) in Cambridge, England.



The Science Center for Avco's Research and Advanced Development Division, as seen in the architects' scale model, is now under construction in Wilmington, Massachusetts, a suburb 15 miles northwest of Boston's cultural hub. Scheduled for completion in early 1958, this ultramodern laboratory will house the scientific and technical staffs of the division.

Avco's new research division is now offering unusual and exciting career opportunities for exceptionally qualified and forward-looking scientists and engineers in such fields as:

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Aerodynamics · Electronics · Mathematics · Metallurgy
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Write to Dr. R. W. Johnston, Scientific and Technical Relations, Avco Research and Advanced Development Division, 20 South Union Street, Lawrence, Massachusetts.

THE NEED TO KNOW

Man has long been motivated by the need to know—to
what lies beyond the oceans, the mountains and the sky; to
what elements make up the earth's crust and what forces c
the universe. Many questions have been answered, but a
knowledge increases and the boundaries of our space expand
questions are asked.

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where we have already made contributions: high-speed ae
namics, ICBM re-entry problems, physics and chemistry
heat transfer, electronic applications to advanced radar
computing, and high-temperature materials.

New ideas for future work are being discussed by the cr
scientists and engineers who are members of this division
scope of these new problems is so broad that the joint effo
those from many disciplines are required for their solution
future promises to be challenging.

A new research and development center, designed to g
proper physical environment and to provide the facilitie
equipment needed, is under construction. The center is lo
near large universities to make available educational opportu
and wide professional contacts.

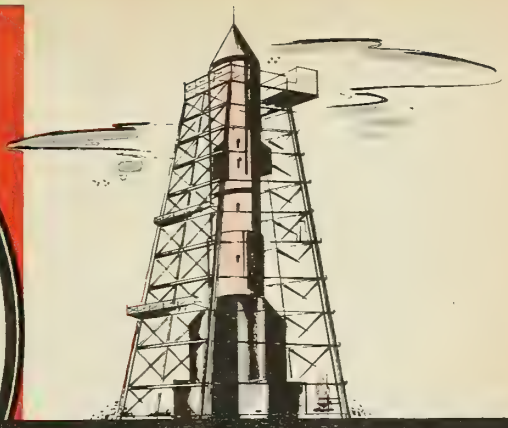
In the short period of our existence as a research and develo
division, much has been accomplished—problems have
solved and we have learned to work together. Now we are l
ning to broaden the scope of our work and to add our con
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Dorothy M. Simon

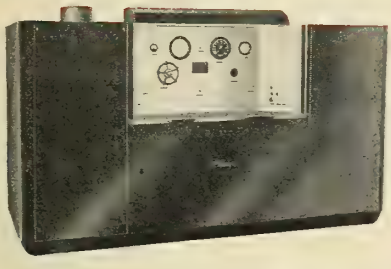
Dr. Dorothy M. Simon
Technical Assistant to the President

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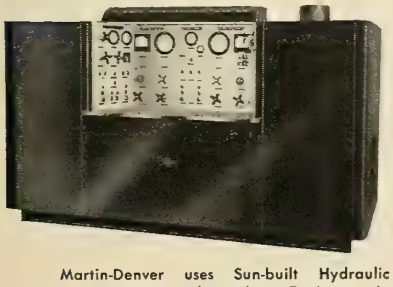




IN THE Final Countdown



Hydraulic Power Source and Auxiliary Testing Units produced for Martin-Denver play an important role in Martin's Missile Projects.



Martin-Denver uses Sun-built Hydraulic Power Source and Auxiliary Equipment in its important missile projects.

Up to the moment the "Fire" button is pressed, a missile is still reliant on the ground support that has prepared it for flight.

Countless tests, checks and rechecks have been made of its power, guidance and weapons systems. Electrically, electronically and hydraulically it is not yet self-sustaining—it must depend upon unfailing auxiliary equipment which fosters its flight.

Just as there is no margin for error in the performance of components once the missile is airborne, so, too, must the ground support equipment function with flawless perfection—the kind of perfection born only of engineering know-how—pride and quality of workmanship.

Sun's engineering and manufacturing capabilities are synonymous with critical precision—infallible performance. Whether it be ground support and auxiliary equipment to prepare a giant bomber, a super-sonic fighter or an intercontinental missile for its appointed mission—look to Sun for major assistance in development and swift "on schedule" production.

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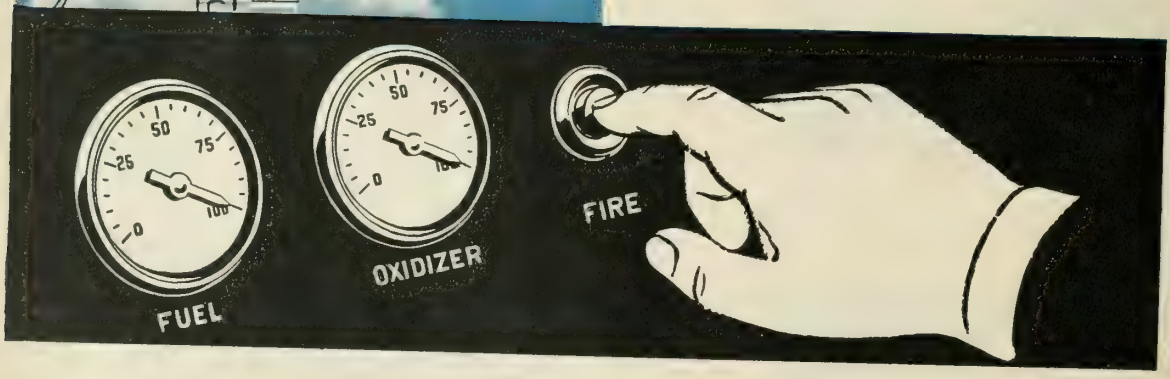
Chicago Aeronautical Division: 6323 AVONDALE AVE., CHICAGO 31, ILLINOIS

Los Angeles Aeronautical Division: 6701 SEPULVEDA BLVD., LOS ANGELES, CALIFORNIA

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missiles and rockets



Staff Scientist Dr. J. W. Muehlner (center) discusses an advanced PDM telemetering system for missile application with K. T. Larkin (left), Telecommunications Department manager, and J. R. Dawley, Telecommunications Systems Section head.

MISSILE SYSTEMS TELECOMMUNICATIONS

Weapon systems programs at Lockheed Missile Systems demand advances far exceeding the current state of telecommunications. Positions are open on the Palo Alto, Sunnyvale and Van Nuys staffs for scientists and engineers possessing a high level of ability and interest in:

TELEMETRY – Research in various areas of physics and electronics related to advanced telemetering projects; theoretical analysis of advanced FM, PDM, PCM System concepts; design integration of all phases of telemetry with weapon systems requirements; conception and development of original high-capacity and high-accuracy systems; development and package design of airborne telemetering equipment capable of operating under extreme environmental conditions, including transducers, subminiaturized subcarrier oscillators, crystal controlled FM transmitters, solid state commutators, PDM keyers, digital storage and conversion devices; development and prototype design of ground telemetry equipment to include devices such as high-efficiency decommutators, calibrators, digital encoders.

COMMUNICATIONS – Application of information theory concepts to challenging communication link problems; analysis and design of microwave communication link components to be utilized in most advanced weapon systems; development and test of television links for special projects.

Address the Research and Development Staff at Sunnyvale 7, or Van Nuys 29, California.



Lockheed

MISSILE SYSTEMS DIVISION

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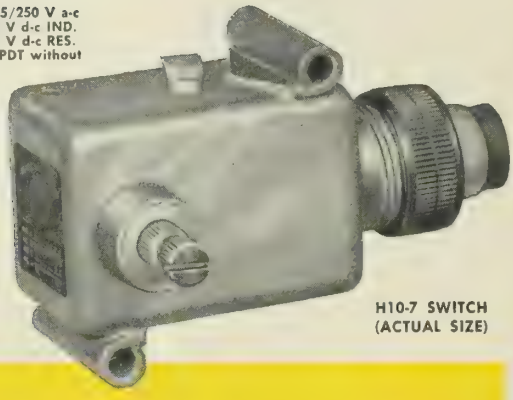
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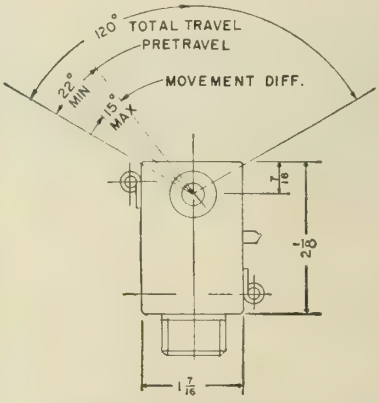
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- No-slip splined shaft — adjustable or fixed actuating arm.
- Permits 120° rotary travel — a minimum of 50,000 cycles!
- Long overtravel eliminates need for fine adjustment; permits greater flexibility in linkage action.
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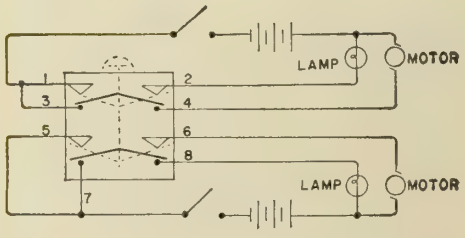
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3-4—Motor driving linkage counter clockwise 120°.

5-6—Switch stopped motor at predetermined position.

7-8—Remote lamp indicates arm at full travel position.

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AUGUST

IAS Naval Aviation Mtg, U.S. Grant Hotel, San Diego, Calif., Aug. 6-10.

Heat Transfer Conference, Penn. State U., University Park, Pa. Sponsor: American Society of Mechanical Engineers, Aug. 11-15.

Symposium on Liquid and Solid Helium and the Statistical Theory of Helium, Ohio State U., Columbus, Sponsor; AFOSR/SRQB—Dates tentative, Aug. 15-22.

Modern Industrial Spectroscopy, Second Annual Special Course, Arizona State College, Tempe, Ariz., Aug. 19-30.

International Ignition Conference, Bendix Scintilla Div., Sidney, New York, Aug. 20-22.

Western Electronics Show & Convention, Cow Palace, San Francisco, Calif., Aug. 20-23.

Int'l Science Radio Union (URSI), 12th General Assembly, Boulder, Colo., Sponsors: AFOSR/SRY, NAS, NRC, ONR, SCEL, Aug. 22-Sept. 5.

American Rocket Society, Symposium on Transport Properties in Gases at High Temperatures and High Pressures, Northwestern U., Evanston, Ill., Sponsors: AFOSR/SRQA, ARS, SQUID, Northwestern U., Aug. 26-28.

American Mathematical Society Meeting, Penn State U., University Park, Pa., Aug. 26-30.

American Sociological Society Annual Mtg. Shoreham Hotel, Washington, D. C., sponsored by AFOSR, Aug. 27-29.

Experimental Aircraft Assn. annual Fly-in and convention, Curtiss-Wright Airport, Milwaukee, Aug. 30-Sept. 1.

SEPTEMBER

Theory of Analytic Functions Conference, Institute of Advanced Studies, Princeton, N.J., Sponsor: AFOSR/SRDB, Sept. 1-14.

Royal Aeronautical Society & Institute of Aeronautical Sciences, 6th International Aeronautical Conferences, Folkstone & London, England, Sept. 1-15.

Society of British Aircraft Constructors, Ltd., 18th Flying Display and Exhibition Royal Aircraft Establishment, Farnborough, Hampshire, England, Sept. 2-8.

International Union of Geodesy and Geophysics. General Assembly, (IUGG), Toronto, Sept. 3-14.

American Physical Society Mtg, Boulder, Colo., Sept. 5-7.

American Chemical Society Mtg., Hotels Commodore, Statler, Park Sheraton, New York, N.Y., Sept. 8-13.

Second Annual Course on Investment Castings, Massachusetts Institute of Technology, Cambridge, Mass. Sept. 8-13.

Aircraft Div. of the American Society for Quality Control, annual conference, Mark Hopkins Hotel, San Francisco, Sept. 9-10.

Twelfth Annual Instrument-Automation Conference & Exhibit, Cleveland Auditorium, Cleveland, Ohio, Sept. 9-13.

American Statistical Association Annual Mtg., Atlantic City, N.J., Sept. 10-13.

Biometric Society Mtg., Atlantic City, N.J., Sept. 10-13.

Institute of Mathematical Statistics Mtg., Atlantic City, N.J., Sept. 10-13.

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Damage Criteria For Shock and Vibration Conference, Cambridge, Mass., Sponsors: AFOSR/SRD (HOST), Interservice Technical Committee on Shock & Vibration, Sept. 12-13.

American Society for Testing Materials, 3rd Pacific Area National Mtg., Sheraton-Palace Hotel, San Francisco, Calif. Sept. 13.

Michigan Aeronautics Conference, sponsored by U. of Michigan transportation Institute, Western Michigan U. and the Aero Club of Michigan, Alpena, Mich. Sept. 26-27.

OCTOBER

Aircraft Production Forum & Aircraft Engineering Display, National Aeronautics Meeting, Hotel Ambassador, Los Angeles, Oct. 1-5.

National Electronics Conf. and forum on electrical research, development and application, Chicago, Ill., Oct. 7-9.

NACA Lewis Propulsion Lab. Triennial Inspection, Cleveland, Ohio, Oct. 7-9.

International Astronautical Federation, 8th Annual Congress, Barcelona, Spain, Oct. 7-12.

ARDO Fifth Annual Science Symposium, Interdepartmental Auditorium (across street from AFOSR hqs). Host Center: AFOSR, Oct. 8-9, Washington, D.C.

Society for Experimental Stress Analysis Nat'l Fall Convention, El Cortez Hotel, San Diego, Calif., Oct. 9-11.

National Noise Abatement Symposium, Sherman Hotel, Chicago, Ill., Oct. 10-11.

Canadia Institute of Radio Engineers Convention-Exposition, Automotive Bldg., Exhibition Park, Toronto, Canada, Oct. 16-18.

ASME Conference on New Developments in the Field of Power, Americus Hotel, Allentown, Pa., Oct. 21-23.

Canadian Aeronautical Institute/IAS Mtg., Montreal, Canada, Oct. 21-22.

Computer Applications Symposium, sponsored by Armour Res. Foundation, Hotel Sherman, Chicago, Ill., Oct. 23-24.

Aircraft Electrical Society annual aviation display, Pan Pacific Auditorium, Los Angeles, Oct. 24-25.

Aeronautical and Navigational Electronics 4th Annual East Coast Conf., sponsored by Baltimore Section. IRE and the Professional Group on Aeronautical and Navigational Electronics, Fifth Regiment Armory, Baltimore, Md., Oct. 28-30.

Association of the U.S. Army Third Annual Mtg., Sheraton-Park Hotel, Washington, D.C., Oct. 28-30.

American Nuclear Society, Henry Hudson Hotel, N. Y. Oct. 28-31.

NOVEMBER

Military-Industry Guided Missile Reliability Symposium, Naval Air Missile Test Center, Pt. Mugu, Calif., Nov. 5-7.

Third Aeronautical-Communications Symposium, Utica, New York, Sponsored by IRE-PGCS, Nov. 6-8.

IAS Weapons System Management Mtg., Statler-Hilton Hotel, Dallas, Tex., Nov. 7-8.

DECEMBER

ASME Annual Mtg., Hotel Statler, New York, N.Y., Dec. 1-6.

American Rocket Society Annual Mtg.. Hotel Statler, New York City, Dec. 2-6.

ARS 1957 Eastern Regional Student Conf.. Sponsored by the Polytechnic Institute of Brooklyn Chapter, Hotel Statler, New York, Dec. 6-7.

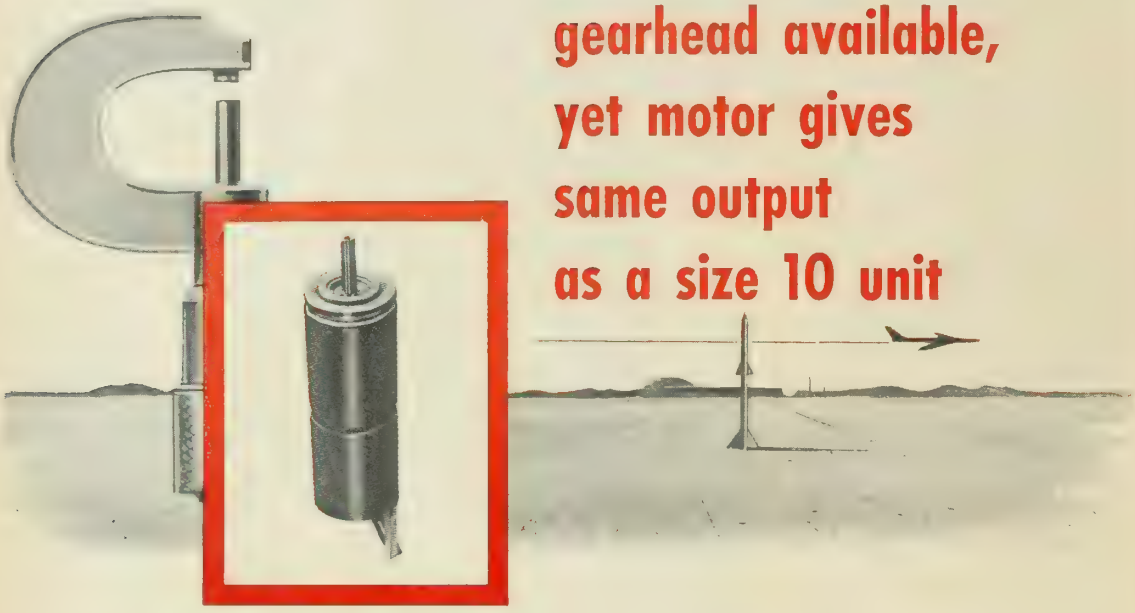


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EDISON'S SIZE 8 GEARHEAD MOTOR

smallest diameter gearhead available, yet motor gives same output as a size 10 unit



OPERATING CHARACTERISTICS:

- Type of motor: Two phase
- No load speed (Min. R.P.M.): 6200
- Stalled torque (Min. in. oz.): 0.20
- Power input at stall (Nom. watts/phase): 1.7
- Speed at max. Power output (R.P.M.): 3950
- Torque at max. Power output (in. oz.): 1.2
- Theoretical acceleration at stall. 16,800 radians/sec.^{2}
- Time constant: 0.0416 sec.
- Duty: Continuous at stall

The Edison Instrument Division has met the challenge of greater miniaturization in servo motors for aircraft and missiles. The size 8 Gearhead Motor shown here is a typical example. This particular Edison unit can be supplied in any gear ratio within 2% and has the smallest diameter gearhead now available. Add to this salient feature the fact that this unit gives the same output as a size 10 motor and you have an ideal motor for such miniaturized projects as small panel mounting instrumentation and small computers for aircraft. Its light weight also makes this gearhead motor easily adaptable for missiles work.

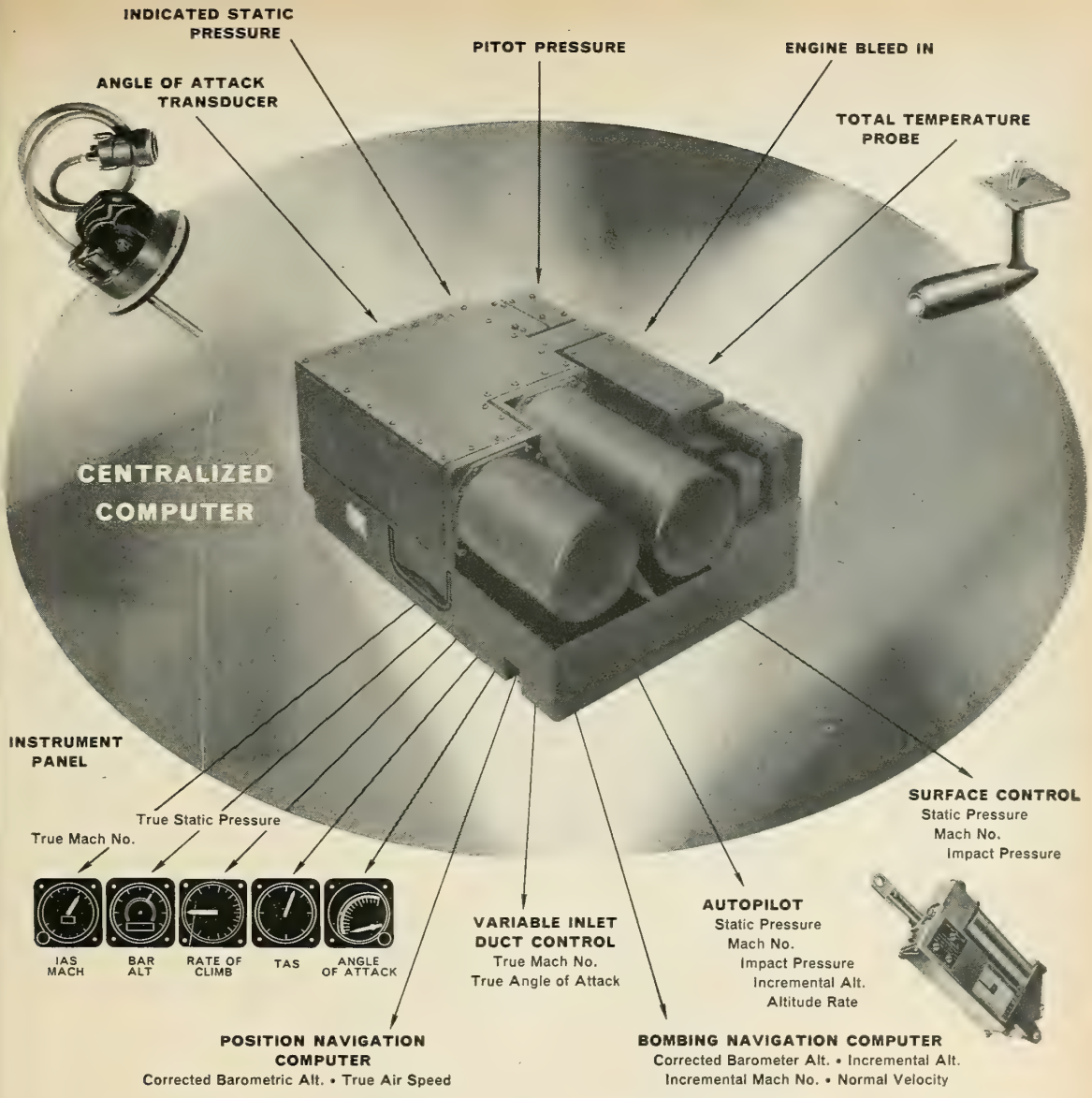
The Edison Instrument Division now has this unit available in production quantities for fast delivery. Permanent tooling assures quality production of both short run and volume orders.

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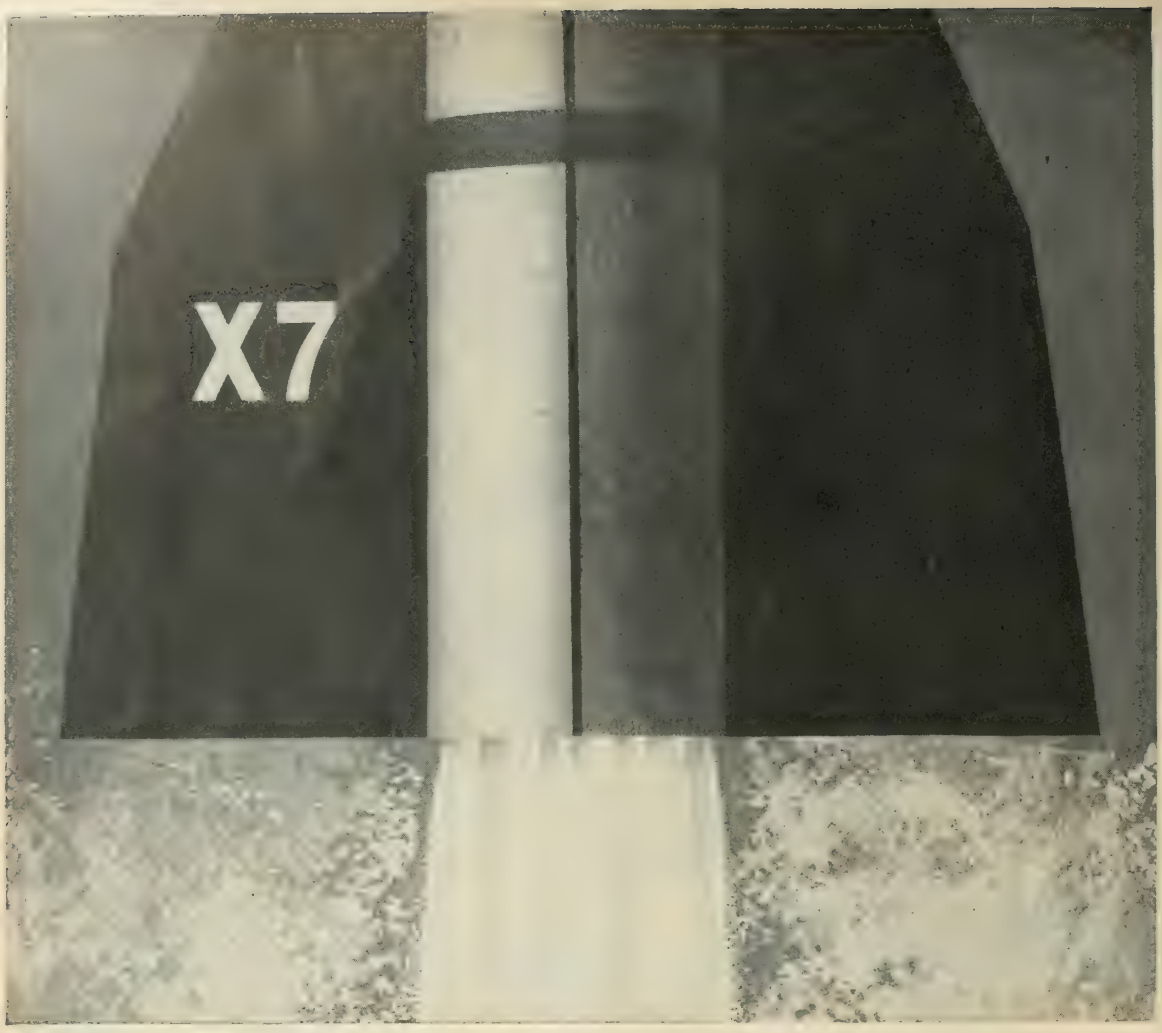
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New punch for missile propellants

High heat of reaction, other characteristics point to magnesium for high-energy fuels

Magnesium, in its finely divided form, may well be suitable for new types of rocket fuels. It has long been known that a tremendous amount of chemical energy is locked within the metal. Upon further examination, finely divided magnesium has many significant characteristics that are important to the development of an efficient fuel:

High heat of reaction
Chemically reactive
High energy per unit volume
High theoretical flame temp.
Can be dispersed in various media
Products of combustion are: inert, relatively non-abrasive and present no toxicity problem
Inexhaustible raw material supply

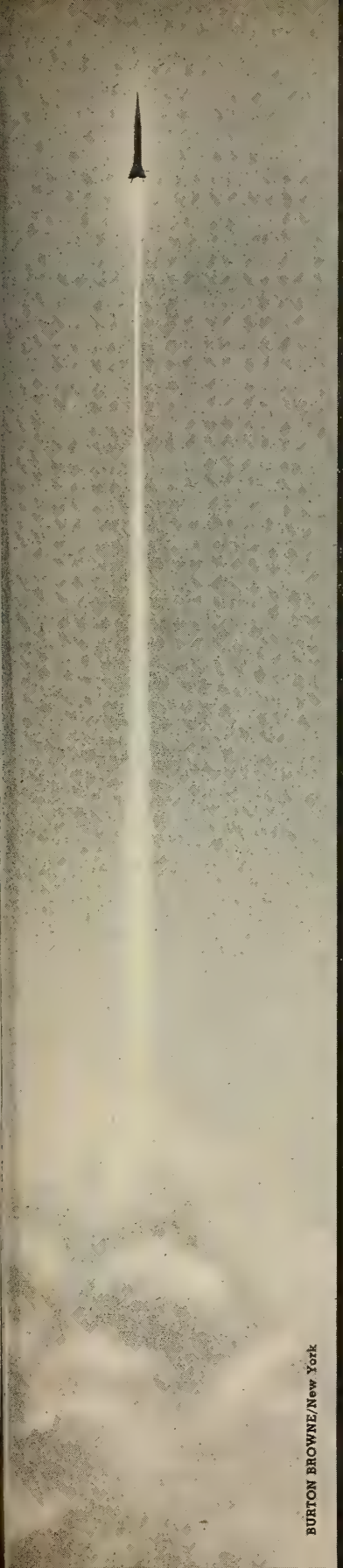
Magnesium's heat of reaction, for example, compares to that of other fuel materials as follows: magnesium, 14,200 B.T.U. per lb. of oxygen required for combustion; aluminum, 13,370; lithium, 10,980; boron, 9,670 (all at 1800°K). This plus magnesium's high theoretical flame temperature indicates that magnesium is especially adaptable for short-range applications where high initial thrust is desirable.

In addition, magnesium can also be considered as an intermediate in the manufacture of other metallic and organometallic fuels.

For information about finely divided magnesium, contact your nearest Dow sales office or write THE DOW CHEMICAL COMPANY, Midland, Michigan, Department MA1438G

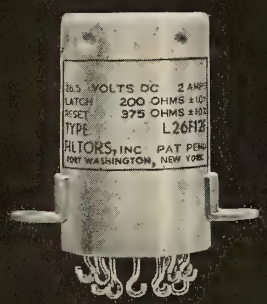
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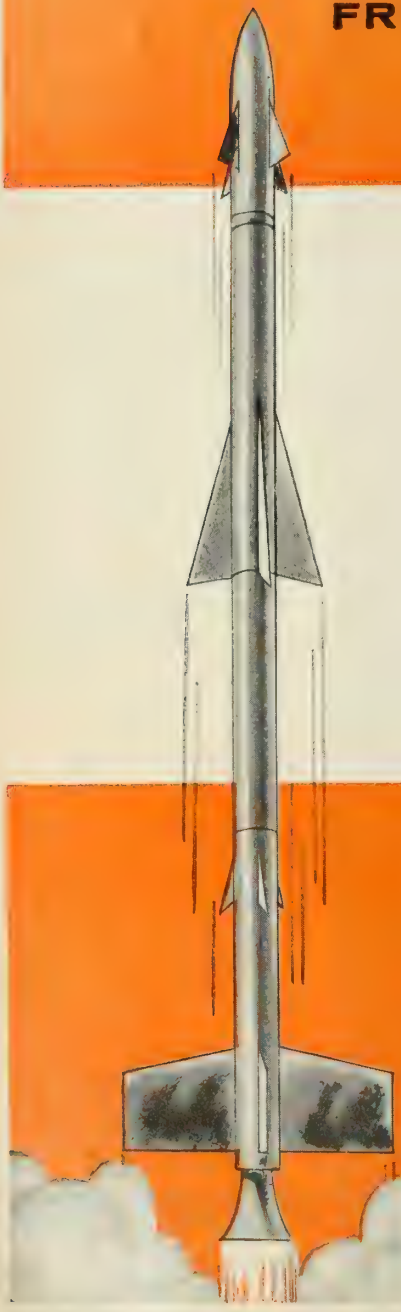
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Experience of the Jet Division includes the forming, welding, and machining of stainless steel, high-temperature alloys, and titanium. Complete heat-treating and testing facilities are available at the Jet Division. Development and engineering of any type of missile component can be handled by the Division's engineering and test sections.

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which describes the experience, facilities and personnel of the Jet Division.



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Soviet IGY Rocket Program Revealed

Claim Satellites Soon; Moon Rockets by '60

In a formal statement by the Russians to U.S. IGY headquarters, the following outline of the Red program for launching of sounding rockets and satellites is revealed:

"The program of the USSR for the IGY includes studies of the atmosphere of the Earth by launching rockets and man-made satellites . . .

"As is known, vertical sounding of the atmosphere by means of rockets has been in progress in our country for a number of years.

"During the IGY we intend to continue and develop this work . . .

"In the Soviet Union, during the IGY the first launching of a man-made satellite with scientific purposes will be made.

"At present there are a considerable number of proposals by Soviet scientists about the employment of rockets and man-made satellites for this or that measurement. The proposals cover practically all the main questions of the physics of the upper layers of the atmosphere and other problems.

"This research is to consist mainly of the following:

"1) Structural Parameters of the atmosphere:

"Measurements will be taken of the pressure, temperature and density of the air at various altitudes and also of the structure of the atmosphere. Together with the measurements of the density taken by manometers, certain data will be obtained by observation of the orbit of the satellite . . .

"2) Optical Properties: The measurements will be made of the altitude and the brightness of the fluorescence of individual layers of the atmosphere, the scattering of light in the atmosphere . . . as well as the optical phenomena on the horizon.

"3) Ultra-violet and X-ray Radiation: The air envelope is a filter for the solar radiation. The atmosphere passes light beams with a wavelength not less than 0.29. The penetration of rockets and satellites into the upper layers of the atmosphere will enable us to study the ultra-violet and X-ray sections of the solar spectrum . . .

"4) Corpuscular Solar Radiation and Aurorae: Corpuscular emission of the sun calls forth sporadic violent variations of the Earth's magnetic field and disturbances in ionosphere . . .

"Solar corpuscules evince several other phenomena in the upper layers of the atmosphere, for instance aurorae . . . It is intended to measure the intensity of the solar corpuscular radiation, to determine the nature of the corpuscules, the velocity of their penetration into the atmosphere, both at calm and during big active processes on the Sun.

"5) Cosmic rays: It is known that the primary cosmic radiation, in the main, consists of hydrogen nuclei (protons), helium (particles) and, in much smaller number, of heavier nuclei (carbon, nitrogen, oxygen, etc.). One of the properties of the primary cosmic radiation is the similarity between the curve of the average distribution of the elements in the cosmos and the curve of the distribution of the shares of the primary component of cosmic radiation. Such elements as lithium, beryllium, boron, are rare in nature and the question regarding the number of their nuclei in the primary cosmic radiation has not been studied by experiment . . .

"Classed with the same range of questions should be the study of the variations of cosmic ray intensity at various altitudes and in different geographical regions.

"6) Ionospheric Physics: One of the problems regarding the structure of ionospheric layers is the determination of concentration of ions. It has been established by experiment that the co centration varies with altitude. In t connection, of great interest are t data on the ionization of the atm phere along the orbit of the satellite, along the trajectory of the rocket.

"The study of the radiowave p sage through the ionospheric layers w in a great measure improve our knov edge of the electronic density, and a regarding the degree of radiowave fa ing. As to other ionospheric measu ments there will be mass-spectromet measurements of the ionic content the ionosphere with a view to the c termination of its structure . . .

"7) Magnetic Fields: The short p riodic variations of the magnetic fie of the Earth are at present associat with the systems of electrical curre flowing in the upper layers of the mosphere. Modern data says that rin of such currents are located in Auro polar zones (in northern and southe latitudes) and around the equator.

The proof of the existence of the currents, their nature and the causes their origin are an important task scientific measurements to be made the satellite . . .

"8) Micrometeors and Meteorit The problem of micro-meteorites is great scientific and practical impo tance. On the one hand, the presen of micro-meteorites in the upper atm phere predetermines a range of phy cal processes influencing the state the atmosphere. On the other han micro-meteorites and meteors prese certain danger for the satellite. Calcu tions show that even small partic with a velocity of 50-70 km per seco can break through the casing of t satellite. Therefore, it is important know the concentration in space a the energy of micro-meteorites . . . solve this task instruments recordi the impacts (impact detectors) of m

teorites will be installed in the rockets and the satellites.

"9) Physical and Chemical Processes in the Upper Atmosphere: It is intended to launch different chemical reagents with the rockets into the upper atmosphere and to study the processes originating during their interaction with the surrounding medium.

"The entire geophysical equipment designed for the investigation of the upper atmosphere is housed in various containers. Some of the containers make up the vanguard part of a rocket with the instruments which is detached from the rocket following a certain time after termination of the engine operation. These Containers reach the altitudes up to 200 km. The containers are equipped with radio telemetry or instruments with immediate photographic recording. In the latter case the containers are saved . . .

The vertical firings of the rockets with a purpose of studying the upper layers of the atmosphere will be conducted in three zones located approximately along the meridian 50°-60° E.

First zone—the Arctic, the Franz Joseph Land, 80° N.

Second zone—middle latitudes of the USSR, 50-60° N.

Third zone—the Antarctic, mainly in the area of Mirny, 50-60° S.

The launching of the satellites will be made from the USSR at a small angle to the meridian. The satellite will revolve around the Earth and will be consequently observed in all the areas of the Earth except the central areas of the Arctic and the Antarctic.

Rocket Distribution by Zones and Years

First zone—1958—25 firings.

Second zone—1957—30 firings, 1958—40 firings.

Third zone—1957-58—30 firings.

"At every firing of a rocket or the launching of a satellite a definite volume of the upper atmosphere investigations is being covered. When the rockets take up the containers of the first type, the study if made of the structural parameters of the atmosphere and of its optical properties, of the ultraviolet and x-ray parts of the solar spectrum, of the ionospheric phenomena and micro-meteorites.

"When containers of the other type are taken up with the rockets, the range of problems studied includes the corpuscular solar radiation, aurorae and also the physical and chemical processes in the upper layers of the atmosphere. When launching the man-made satellites the programme includes geophysical, physical and astro-physical experiments in various combinations, and also other investigations such as the observation of the relativity theory effect, the study of the shape of the Earth.

"The firing of the rockets and the satellites will be conducted approximately evenly throughout the International Geophysical Year mainly on World Days and on occasions of active solar processes, Special World Days."

The official Soviet schedule calls for the first research rocket activity around the moon by the early 1960s.

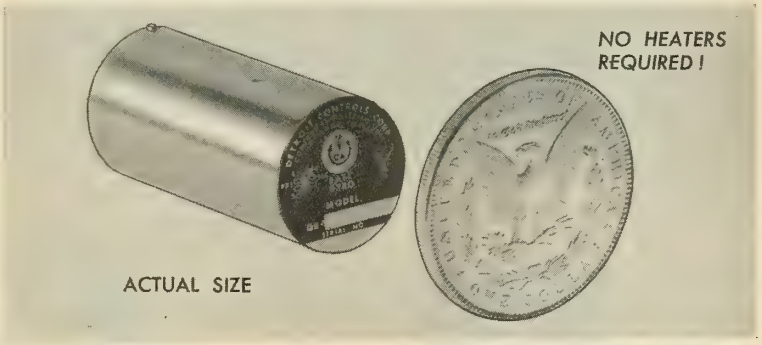
This is announced by Yu. Khlebtsevich, chairman of the Soviet Technical Committee on Radio-Television Guidance of Rockets. These moon rockets will carry no humans, only radio and TV installations to report data back to the Earth.

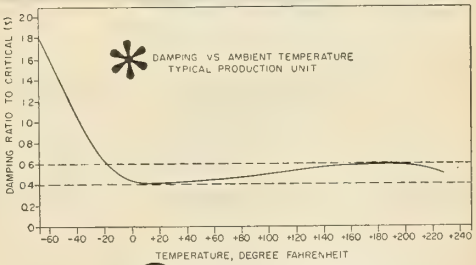
The first unmanned rocket to the moon will be a small tank containing a laboratory — "a tankette-laboratory," Khlebtsevich calls it. This can be sent on its flight with no more than 250 tons of fuel.

"Moving upon the moon's surface," explains the Soviet scientist, "the tankette will incessantly take films and relay them to the Earth as television.

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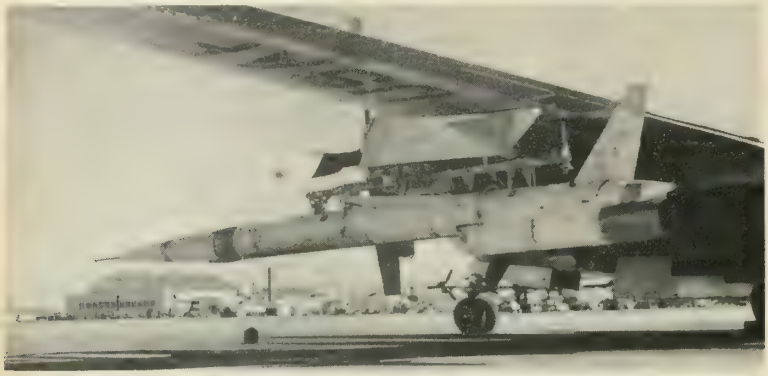
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AF Reveals XQ-4 Supersonic Target Drone

The turbojet XQ-4 target drone, partly released from security wraps, marks an outstanding advance in the development of high speed targets. Developed by Radioplane Co., a subsidiary of Northrop Aircraft, Inc., the XQ-4 will provide a more reliable evaluation of present air defense systems.

Resembling a scaled-down *Snark*, the drone will travel at supersonic velocities above 60,000 ft. It has both ground and air launch capabilities and is recoverable by three-stage parachute over land or water. XQ-4 is approximately 35 ft. in length and 2 ft. in diameter. Payload volume is sufficient to accommodate special tracking, scoring and photographic or television reconnaissance installations.

Several highly successful flight tests have been achieved at Holloman Air Force Base, N. M. All tests were conditioned by the Radioplane Co.



USAF XQ-4 supersonic target drone shown mounted on the wing of a B-50 launch aircraft. Except for short thin wings, it bears a remarkable resemblance to the SNARK.

RATO Costs Reduced H_2O_2 Still Expensive

As reflected in a recent purchase order by the Navy Bureau of Ordnance, solid propellant RATO costs have taken a welcome drop. In the order Aerojet will deliver 22,630 units (15KS-1000) plus some spare igniters for about $155 a piece. Thus, hardware plus propellant cost for this unit is about $1.07 lb.

On the other hand, hydrogen peroxide is still an expensive item. Redstone Arsenal purchased 52,500 lbs. (half 90% CP-rest, 76%) for $29,859. This represents an average of $.57 .lb or about $.80 for the 90% material.

Martin Orlando Plant Nears Completion

Martin Company's Orlando plant, covering a 7000 acre tract and containing 500,000 square feet in four buildings, takes shape southwest of the city. The plant, under construction since April 2, will produce small weapons, guided missiles and electronics components. Scheduled for completion late this year, the facility will turn out *Lacrosse*, *Bullpup* and the Missile Master system.

ANOTHER Bendix ACHIEVEMENT

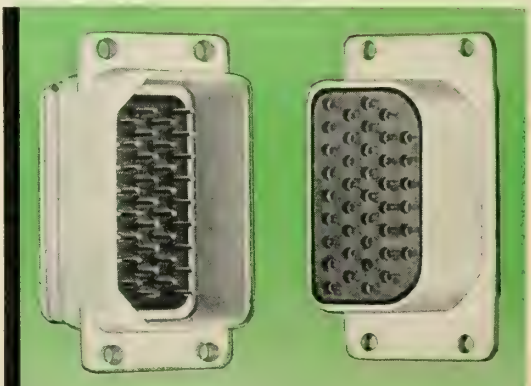
A resilient insert rack and panel connector

Here is the new and improved Bendix Type SR rack and panel electrical connector with outstanding resistance to vibration. The low engagement force of this connector gives it a decided advantage over existing connectors of this type.

Pressurization is easily accomplished. The resilient inserts press firmly against the shell wall holding the contacts in exact position. Insert patterns are available to mate with existing equipment in the field.

Adding to the efficiency of this rack and panel connector is the performance-proven Bendix "clip-type" closed entry socket.

Here, indeed, is another outstanding Bendix product that should be your first choice in rack and panel connectors.



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Nickerson Assigned to Panama Canal Zone

Col. John C. Nickerson, Jr., former technical coordinator at Army Ballistic Missile Agency, Huntsville, Ala., has been transferred to the Panama Canal Zone where he will have access to nothing more classified than "confidential." Thus closes one of the most colorful chapters in the still-running ballistic missile serial: Army vs. Air Force.

Col. Nickerson had been accused of espionage, perjury and failing to safeguard classified material. The more serious charges of espionage and perjury were withdrawn, however, when he pleaded guilty to the lesser counts.

Nickerson wrote "Considerations on the Wilson Memorandum," wherein he compared Army and AF progress in missile development and detailed why Army should have responsibility for firing Intermediate Range Ballistic Missiles. Little in the document would probably have been considered by a court of law as "classified" from a military security viewpoint. Politically, however, it was "too hot to touch." Col. Nickerson sent copies to selected Members of Congress, certain Washington columnists and MISSILES AND ROCKETS magazine.

Trouble began when a newspaper columnist caused it to be brought to Defense Secretary Wilson's attention. He demanded an immediate investigation by Army Secretary Brucker.

The crux of the prosecution's case, however, was not this document. In what was a completely unsolicited and apparently naive effort to provide m/r with background information on the Army's missile progress, he mailed certain official documents via registered mail to this magazine. Each was clearly marked "Secret" and was returned unread via registered mail to the sender. Army investigators, however, found a transcript of the covering letter from Nickerson to m/r. The prosecution based its main case on the fact that Nickerson sent these documents to unauthorized persons.

Col. Nickerson was fined $1500 and suspended in rank for one year. Huntsville citizens took up a collection to pay his fine and legal costs.

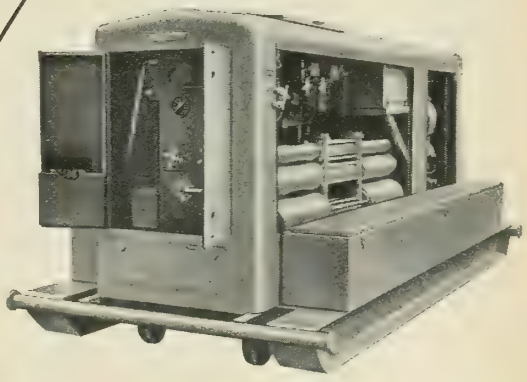
Redstone Equipment Stored Underground

HUNTSVILLE, Ala.—A housecleaning operation at one of the world's most modern scientific installations, Redstone Arsenal, has used ancient means to achieve its purpose.

River barges and caves are being used to store more than 500 tons of

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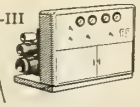
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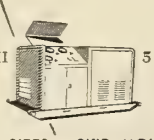
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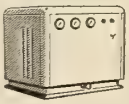
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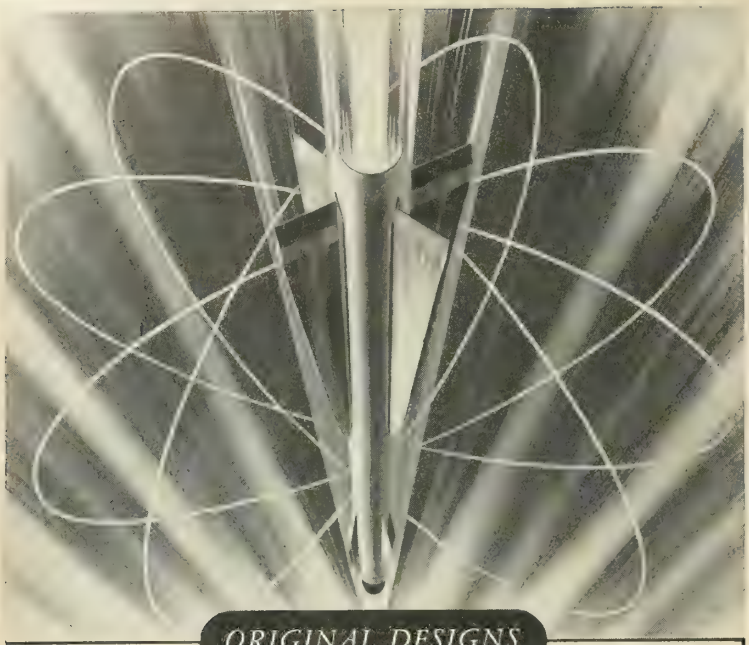
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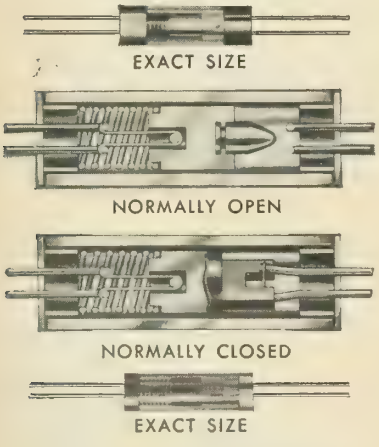


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heavy strategic production equipment which was shipped here following World War II for storage against possible future needs.

The Redstone Arsenal's Tennessee River docks were used for the first time for outbound freight in the shipment of 179 pieces of machinery, some weighing as much as 15 tons, via a circuitous but economical route to a vast cave near Atchison, Kansas, for storage. The operation is said to have saved the Army $20,000 as compared with the cost of other transportation.

The Redstone docks are normally used to receive shipments of materials from the atomic plant at Oak Ridge, Tenn., which is upstream on the vagabond Tennessee River that has its source in North Carolina and winds up as a tributary of the Ohio River near Cairo, Ill. The Ohio then flows into the Mississippi. The Redstone barges followed this route, turned up the Mississippi into the Missouri River and delivered their freight at Atchison above Kansas City. Five days were required for the operation.

The docks at Redstone are also used to receive shipments from the Muscle Shoals plants of Reynolds Metals Co.

First *Redstone* Battle Group Activated

HUNTSVILLE, Ala.—The first battle group for field operation of the big *Redstone* bombardment missile will be activated by the Army here on Sept. 9th. It will consist of about 600 men, a battalion divided into two batteries. Each battery will be equipped with one mobile launcher for the 60-foot missile.

The new group will be formed around the 217th Field Artillery Battalion which has been in training for a year to develop field operating techniques for the *Redstone*. The group will also include the 630th Ordnance Company and the 580th Engineer Company.

Lacrosse Course Concluded Aug. 6

HUNTSVILLE, Ala.—The Army will have 150 well-trained teachers for maintenance and fielding of the new *Lacrosse* anti-aircraft and artillery missile when a special course of instruction ends here in early August. They will be deployed immediately to White Sands Proving Grounds, New Mexico, to the Artillery Guided Missile School, Fort Sill, Okla., and to the Marine Corps where they will teach the missile techniques to other instructors.

Far Side: Bargain Counter Space Exploration

America's first stride into interstellar space will begin with the quiet softness of a gentle Kona breeze. In fewer than 60 days on a Polynesian atoll in the Central Pacific, a glistening 3,750,000 cubic foot polyethylene balloon will be hooked to its payload, filled with helium and at the precise moment, cut loose. Several hours later and 100,000 feet above the earth's surface, the four first stage motors of Project Far Side's space exploration vehicle will fire with a combined thrust of 160,000 pounds. The straining balloon will be ripped assunder, and for the next few minutes the tiny transmitter in the missile's nose will telemeter back measurements of space conditions within "the immediate environment of earth"—up to some 4000 miles out.

This will be the first of six Project Far Side firings planned for this fall. Though none will include a try at the moon, success of the series will certainly put this next on the list. It is a coming objective of major scientific importance.

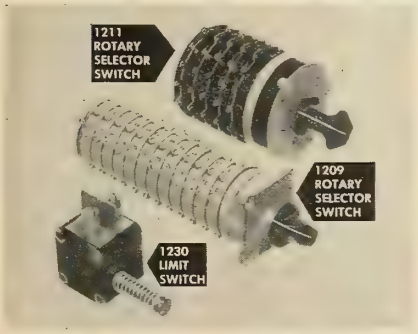
MISSILES AND ROCKETS magazine announced exclusively in its April issue this year that AFOSR was working on various moon rocket projects. Far Side is the beginning. The details of this



MISSILES AND ROCKETS editors Norman Baker and Seabrook Hull examine cosmic ray sensor and circuitry to be launched with the instrumentation in Air Force Office of Scientific Research Project Far Side's space exploration vehicle. This circuitry is designed under contract by Maryland University. In the inset is the full instrument package with battery, transmitter, other circuitry. Aeronutronics Systems, Inc. makes the complete unit.

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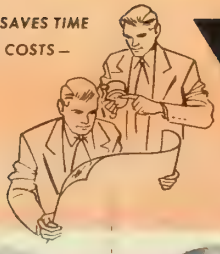
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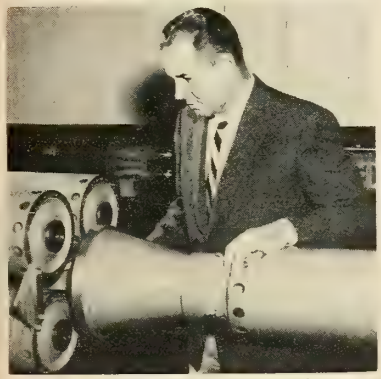
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historic project have been confirmed to m/r by Brigadier General H. F. Gregory, Commander, Air Force Office of Scientific Research, Air Research and Development Command.

If Project *Vanguard* is costly and encumbered in a plethora of red tape, Far Side is pleasantly simple and might have lifted its cost figures out of a mail-order catalogue (see editorial, p. 11). Consisting of 10 solid propellant rockets divided 4-1-4-1 into four stages, the Far Side vehicle uses strictly off-the-shelf items.

Stage one consists of a cluster of four *Recruit* rockets built by Thiokol Chemical Corp. Stage two is a single *Recruit*, and is located centrally forward of the first stage. Stage three, tacked onto the nose of number two, is a cluster of four *Arrow II* rockets made by Grand Central Rocket Co. *Arrow II* is a souped up *Loki*. The fourth stage, a single *Arrow II*, is nestled concentrically in the third stage. Both the *Recruit* and *Loki* were originally developed under U.S. Army contracts.



Project Director Herbert L. Karsch, Aeronutronics Systems, Inc., examining forward end of the first and nozzle of the second stage of the Far Side vehicle. The motors are RECRUITS. Note last two stages beyond.

The overall length of the vehicle is about 23 feet. Its diameter ranges from less than two feet at the first stage (excluding cruciform fins of less than 20 inches net additional total span) to about eight inches for the second stage and less than 12 inches for the clustered third and fourth stages. The weight of the vehicle itself is 1900 pounds. Including its launching cage, external power supply and radio gear, etc., the weight that will be carried aloft by the balloon comes closer to 2300 pounds.

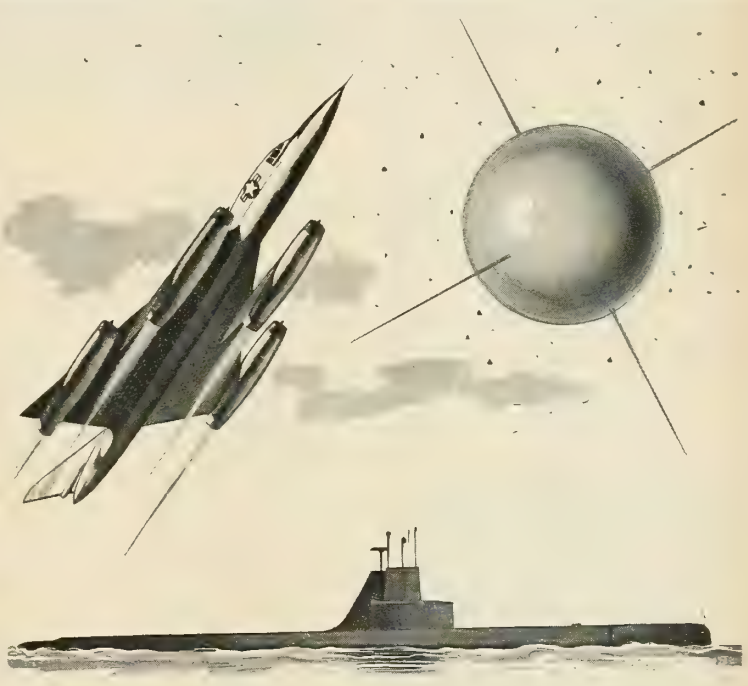
The balloon itself weighs another 1500 pounds and reaches a diameter of 200 feet at altitude. It was designed and is manufactured by the Mechanical Division of General Mills, Inc.

The Far Side rocket vehicle's payload will consist of an instrumented package roughly six inches long, four inches in diameter and weighing about three-and-a-half pounds. The main measurements to be made will be ion density, magnetism and cosmic rays. All will be single-purpose measurements. The entire instrument package will be enclosed in white foam of density three pounds per cubic foot. All circuits are 100 per cent instrumented.

Actual on-board cosmic ray instrumentation, including geiger detector tube, high voltage supply for the geiger counter, scale of 64 with associated preamplifier and emitter circuits. Power consumption is 100 milliwatts. In charge of this phase of the work is Maryland University's brilliant young astrophysicist, Dr. S. Fred Singer, described by AFOSR as "one of the nation's leading authorities in the field of upper atmosphere research." The instrumentation is being put together by University of Maryland students under Dr. Singer's direction.

The Ford Motor Co. subsidiary, Aeronutronics Systems, Inc., is prime contractor for Project Far Side and is responsible for designing, fabricating and firing the vehicles. Far Side Project Manager for Aeronutronics is Herbert L. Karsch.

Project Monitor for Far Side is AFOSR's Director of Advanced



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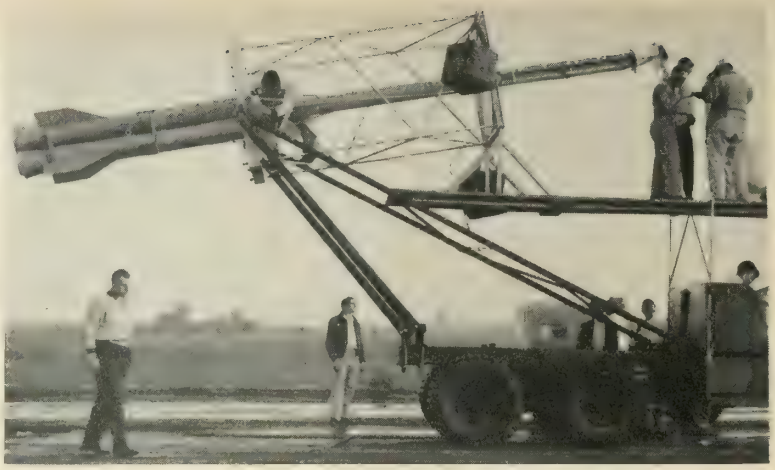
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Four-stage Far Side rocket plus its firing platform are mounted on a truck prior to hooking onto 3,750,000 cubic foot General Mills balloon in preparation for June test flight.

Studies, Dr. Morton Alperin, who emphasizes the importance of obtaining heretofore unavailable data vital to the AF of today and tomorrow.

The actual altitude that will be reached by the Far Side rocket can only be estimated. Current lack of knowledge of the precise density distribution at ultra-high altitudes makes reliable calculations difficult. However, the four stages will fire for a cumulative time of 26 seconds (eight seconds actual firing time plus coasting stages) with a maximum acceleration of 200 g's. During this period the missile is expected to achieve a velocity in excess of 17,000 miles an hour—out where Mach Number is a meaningless unit.

Those participating in the project forecast only that the final stage will achieve a distance out from Earth of "from 1000 miles to several times that distance."

If current estimates of "air" density in space and of the diminishing effects of gravity are anywhere near correct and if the solid propellant rockets work as they should in the pressureless, highly ionized environment in which they will be firing—the expected distance is calculated at between 4000 and 5000 miles. The mean distance of Moon from Earth is 239,000 miles.

However, at 5000 miles out, the force or acceleration due to gravity, is only a little over six feet per second per second, compared to 32 on the earth's surface, and reducing steadily with the distance from the earth's center. No official suggestions have been made by AFOSR that it would take only "a little more push" to get a vehicle into the Moon's gravitational field. However, some of those closely connected with the project have admitted freely that it is not beyond the limit of either current balloon or off-the-shelf solid propellant knowhow to use this method for either orbiting or impacting the moon.



Scientists recapture first project Far Side test load after it reached 106,000 feet before dropping back to earth by parachute. First business shot is scheduled for September.

Circle No. 53 on Subscriber Service Card.

Rocket Trends

by Erik Bergaust



MID-OCTOBER MAY MARK the "turn of the century" for U.S. missiles . . . Complete shake-up by that time by the Department of Defense is understood to have been ordered by the White House to eliminate duplications and to step up efficiency in development . . . Some will lose, some will win . . . *Triton*, for instance, might get the ax, although this may be due to the rapid advancement in solid propellant technology.

AIR-TO-GROUND MISSILE RACE is on. Air Force officials seem to think Rascal-type missile (with improved range, speed) will be the next thing for boosting our strategic retaliation capability. Tomorrow's big bombers (including our B-52s) will become missile carriers exclusively. Industry is now bidding on new air-to-ground bird . . . In the lead, coming down the home stretch: Lockheed and North American . . .

DID WE MISS THE BOAT IN THE IRBM-ICBM race with Russia? It is said that had we poured the same money into a solid propellant program, we could have had operational IRBM's and ICBM's by now. Just as the solid *Nike Hercules* is replacing *Nike Ajax*, we can do the same for the IRBM-ICBM. And we probably will . . .

UNDERWATER MISSILE RACE is getting hotter and hotter . . . look to lithium as important underwater missile "fuel". If you want some capital gains from promising chemical suppliers to the solid field you might want to try Foote Mineral, American Potash & Chemical, or Lithium Corp. They will be making all the lithium perchlorate which is the hottest item to hit the solid propellant field. AmPot is the favorite since it will also cash in on the boron fuels, though Foote is a major lithium supplier to AEC.

RELIABLE SOURCES SAY Standard Oil Co. (Ind.) wants somebody to take over its Seymour, Ind. activities for solid propellant work . . . American Rocket Co. is said to be seeking somewhat smaller pile for its current expansion program.

RED CHINA MAY BECOME SOLID ROCKET PRODUCER since they will buy the following important rocket chemicals from Britain and Norway: ammonium nitrate, cellulose nitrate, lithium compounds, potassium chlorate, potassium dichromate, potassium nitrate, potassium permanganate, sodium chlorate, sodium dichromate, sodium nitrate, and sodium perchlorate . . . University of Moscow is working on the acceleration of lithium, sodium, potassium, rubidium and caesium ions as potential space rocket propulsion systems.

DOUGLAS AIRCRAFT ABOUT TO BECOME LEADER of U.S. missile builders? Stepped-up NATO missile negotiations (most NATO missiles will be Douglas birds . . . *Nike*, *Honest John* etc.) and recent successful tests of AF's atomic MB-1 . . . plus BIG *Nike Hercules* contract coming up . . . indicate Douglas will take missile production lead for a good while.

COKEBOTTLE DESIGN CONCEPT (area rule) may be employed in missiles. Army missile men are reported to be considering Marilyn Monroe-shaped IRBM's and even ICBM's to lick early drag problems . . .

The *Vanguard* Engine Passes Qualification Test

As far as power plants are concerned, Project *Vanguard* is ready to go. At least that's the status insofar as static qualification tests are concerned. Three of the four *Vanguard* engines under contract to The Martin Co. have passed with flying colors. Rumors are, however, that the fourth company, Allegany Ballistics Laboratory (subsidiary of Hercules Powder Co.), wants out.

General Electric Co.'s long-in-doubt first stage engine, m/r has learned, passed its complete qualification test "without having to replace anything"—not one single part.

Aerojet-General, so far, has had two second stage engines accepted—the first on April 24 and the second on May 16.

Grand Central Rocket Co. has not only had its third stage engines accepted, but one has flown with "100 per cent perfect" results.

These facts remove a major factor of doubt from the possibilities of success of Project *Vanguard's* efforts to place a man-made earth satellite in an orbit during the International Geophysical Year. Though the need for refinements may become apparent as the first and second stage engines are subjected to actual flight tests, it must be heartening to Naval Research Laboratory and Martin that at least they work on the ground. It's a big step towards consummation.

GE's first stage engine has completed between five and ten full duration tests of 150 seconds each without any parts having to be replaced. GE believes that this places the life of their engine over that of any other engine of comparable performance. Nearly all the engines called for in the contract have been delivered.

Reason for failures of the first three engines delivered appears to be (believe it or not) that they had gotten rusty . . .

The fact that Aerojet General reports only two engines accepted so far indicates that this company is probably not so far advanced as GE in production. Development, however, appears to have been completed. *Vanguard* test vehicle TV-2 will probably be fired in a few days and will be the first flight test of GE's first stage. Soon thereafter, TV-3 will be fired, including a GE first and an Aerojet second stage. This should occur within six weeks.

Aerojet-General, in developing the thrust chamber for its second stage engine, worked out a system of wire wrapped aluminum tube construction with amazing weight to size advantages. This system is regeneratively cooled.

Assuming everything else to be in a similar state of preparedness as these three engines, it would seem that the possibility of advancing the date for a first business try at getting the 20-pound sphere in an orbit has improved. Statements, however, from those in authority in the project continue to be cautious—"in the spring of 1958; before the end of the IGY, etc."

Meanwhile, unofficial Lockheed Aircraft spokesmen would have you believe that an upward misfire of the third stage of an X-17 had already placed man's first uninstrumented satellite in orbit. Concern grows lest Russia in fact places a satellite in orbit on September 17, the 100th anniversary of Soviet space flight pioneer Tsiolkovsky's birth. This would be embarrassing. Meanwhile, Air Force Office of Scientific Research is piling Army rockets together in an attempt to accomplish man's farthest excursions into outer space.

Recruit's and *Loki's* for Outer Space

Five *Recruit* and five *Loki* rockets will be assembled into four stages to complete the AFOSR's Project *Far Side* space flight vehicle (this issue, p. 45). Reliability of rocket powerplants should not be a factor threatening project postponement or malfunctions during actual launch operations. Evaluation test firings will be eliminated on Project *Far Side*. All shots will be for real.

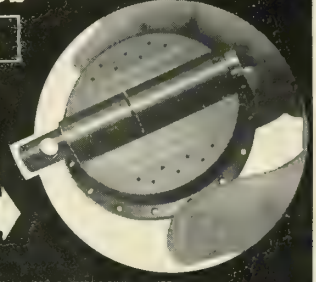
And still there is no word of what Redstone Arsenal is doing with all its *Recruits*.

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Missile Business

By Seabrook Hull



SECRET CONTRACTS SECRETLY ARRIVED AT, lack of competitive bidding and tax supported facilities for private industry are main reasons behind current Congressional efforts to change military procurement rules. Some figures Congress doesn't like: Of $13.6 billion total military buying in first nine months, 1956, 92 per cent was by negotiation instead of advertised bid; 39 per cent was negotiated in secret; and 22 per cent required a substantial initial investment of government funds. All-told, 17 exceptions to normal procurement procedures had been invoked to justify these actions. Congress aims to cut that list sharply. Law may pass this year. It would hit missile procurement heavily.

Passage would make it tougher for Services to direct procurement where they want it to go, for whatever reason. Company contracting officers would have to get used to new rules, bid closer to the cost line and in general become adept at more rough-and-tumble ways of doing business.

A PERMANENT ARMS INDUSTRY—anathema though it may be to traditional American concepts—may be the best answer. Business and procurement methods that work best in temporary all-out conditions of a conventional "hot war" obviously leave much to be desired over 20-to-50 years of cold war. A really comprehensive new look may be required.

FOREIGN SALES OF U.S. MISSILES will be largely handled through regular U.S. military channels. This doesn't mean, however, that it wouldn't pay U.S. missile makers to do a little personal salesmanship with NATO officials in position to make decisions. This could influence NATO-wide determination of West European missile requirements.

Two countries for sure, Britain and West Germany, and maybe Luxembourg, will pay their own way and may buy directly from manufacturer.

Only missiles that have been announced as being "cleared" for export are *Nike*, *Matador* and *Honest John*.

Possible big market exists for enterprising missile maker that comes up with a low-cost "prestige" missile for sale in Middle East, South America. These countries would like to have their armed forces geared to the missile age but could never afford high-cost, complex birds such as those being developed for U.S., NATO, etc.

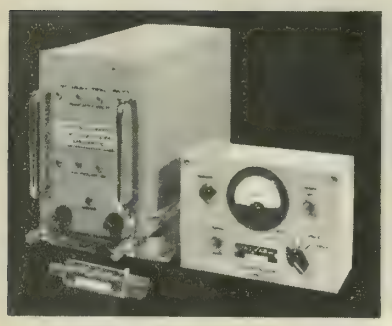
MEANWHILE, COMPETITION PATTERN IN MISSILES develops. Japan's applied for permission to manufacture Swiss Oerlikon-56 rockets. French have radio-guided anti-tank SS-11, renamed it SS-22 and are trying it out as an air-to-air missile. Norway boasts air-to-underwater *Tern*. Sweden is buying Australian ground-to-air *Jindiviks*. Prices count abroad.

DEATH OF *NAVAHO* plus forecast death of Navy's *Triton* project carry serious implications for "next step" development in air transport; could kill all development on large ramjets. Similarly, one of most practical approaches to regular manned space flight involves attainment of initial high velocity with ramjets before cutting in ion propulsion. There are other factors, both military and civil, that leave proposed abandonment of advanced air breathers open to serious doubt. Development of effective anti-ICBM missile will obsolete a lot of costly hardware overnight, and cause a serious flip-flop in the balance of power—unless U.S. has something else in its arsenal, like *Navaho* or *Triton*.



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Hughes Latest *Falcon* Has Infra-red Seeker

The latest in the *Falcon* GAR air-to-air missile series is now in operation as a U.S. Air Force defense weapon. New *Falcon*, GAR-2A, is equipped with an infra-red radiation seeker greatly increasing the kill rate over earlier *Falcons*. GAR-2A is actually a GAR-1D with the IF guidance system replacing the radar system.

All-weather interceptors, F-102A, F-89H, and F-101, will carry both IF and radar equipped *Falcons* to insure kills under all weather conditions. Missiles will be fired in salvos of three to six as a condition of calculated kill



probability of 80-90%. The pilot may select the type and number of missiles to be fired once the control system has established the target.

Air Force officials announced that they would continue to hold the Navy *Sidewinder* in high regard as armament for day fighters. "The *Sidewinder* is a more simple weapon while the *Falcon* GAR-2A is more sophisticated and versatile". Main objection to the *Sidewinder* apparently is its length—requiring external installation.

Test firings of the new weapon were made at Holloman Air Development Center, N. M. For these tests *Matadors* and F-80s served as targets. Although all tests were conducted without warheads, each intercept destroyed the target.

INTERNATIONAL NEWS

By Anthony Vandyk



Swiss Reveal Details of Oerlikon AAM

Oerlikon has released full information on its 5-cm and 8-cm aircraft rockets with folding fins. These rockets are for use not only against aircraft but also against ground targets such as armored vehicles, armor trains, artillery. Oerlikon describes the distinctive features of its armament as: (1) quickness in action; (2) excellent accuracy; (3) high lethal power. It points out that the rockets are: (a) safe to transport; (b) capable of being stored for an indefinite period; (c) extremely safe to handle.

Multiple launchers are used for the rockets. The launchers are made in various shapes (one was illustrated in the July m/r, page 83) and with various capacities according to the type of aircraft and mission required. A typical launcher containing 76 5-cm rockets weighs about 660 lbs. empty or 1200 lbs. loaded. The launcher has no effect on the flight characteristics of the aircraft except for slightly reducing speed. It may be dropped in emergencies.

The rockets are electrically ignited by means of a selective triggering built into the cockpit and can be fired singly or in automatic fire. To avoid mutual interference during flight when firing in automatic fire, the rockets are fired in pairs at time intervals of 0.1 seconds.

During a demonstration for a foreign air force Oerlikon reports that 72 5-cm rockets with folding fins were fired from Meteor Fighter in a series of automatic firings from air to ground to demonstrate the killing power and firing accuracy of the weapon. The firing started at altitude of approximately 4000 ft. and ended at an altitude of about 1500 ft. The total firing time was approximately 3.5 seconds. The rate of fire is equivalent to 1200 rockets per minute. During the demonstration the rockets were dispersed over an area about 60 ft. long and 25 ft. wide. A total of 24 hits were made on a cloth target measuring 19 ft. by 19 ft.

The following technical data referred to the 8-cm rocket with folding fins: initial weight, 20½ lbs.; maximum velocity (fired from ground), 2756 ft. per second; weight of explosive (Hexal), 2 lbs.; thrust (approx. 1 second), 1587 lbs.; burning ends after approximately 1411 ft.; length of rocket 3 ft. 11¾ in.; armor guessing ability, 1 ft. 2½ in.

The rocket is manufactured by Oerlikon in the following versions: practice rocket (inert), practice rocket with marking charge; explosive rocket with impact fuze; and armour piercing rocket with hollow charge.

The folding fins open approximately 0.05 seconds after leaving the launching tube. During this period the rocket covers a distance of approximately 10 ft.

The characteristic properties of the rocket motor are: rocket motor with parallel beam jet; spring actuated folding fins in which all fins open

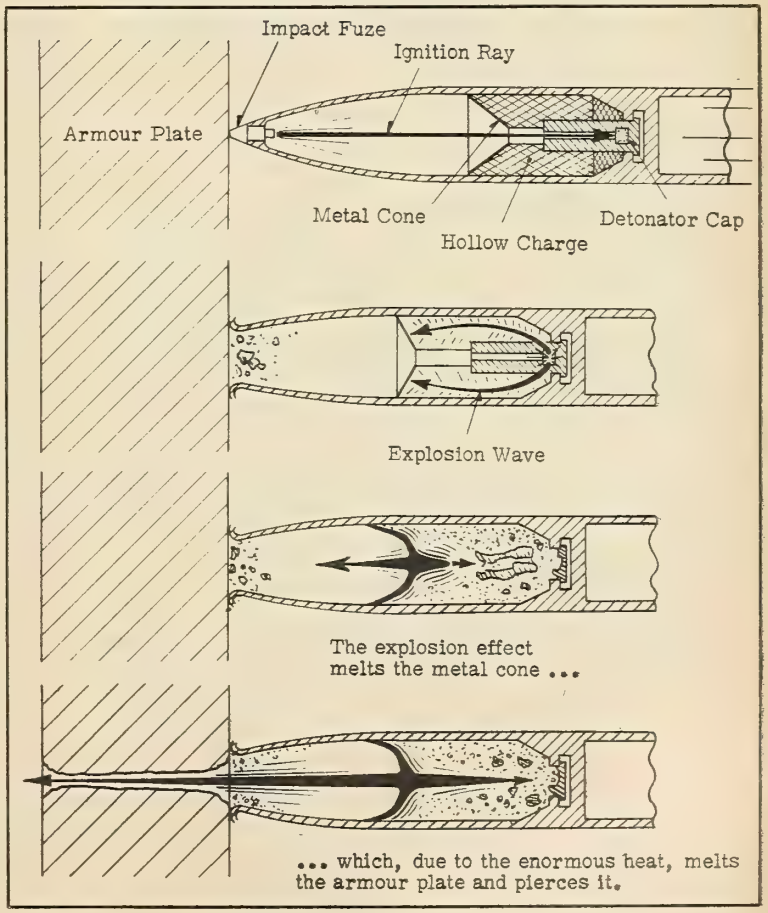


Diagram shows how a rocket with hollow charge operates as an armor-piercing weapon.



simultaneously by direct action; slight twist due to guide veins inside the nozzle; and electric ignition by means of a contact ring at the end of the nozzle.

Mitsubishi Electric Machinery Co., Ltd., has applied to the Japanese government for permission to pay Buehle Contraves & Company of Switzerland for the patent rights for the production in Japan of Oerlikon guided missiles. A provisional agreeement gives Mitsubishi all the patent rights for the production in Japan of the *Oerlikon-56* and its fire control system.

The Swiss firm is asking 8% as patent rights of the *Oerlikon* missiles and 5% of the revenue from sales of launchers and firing control system. The contract is to be valid for 15 years. It will be two or three years before Mitsubishi can start mass production in Japan of guided missiles because of government permits, preparations and completion of final contracts with the Swiss firm.

The Japanese Defense Agency this fall will import a complete set of *Oerlikon-56* rockets and a launcher from the Swiss firm at a cost of $1,080,000 with the aim of studying and testing the Swiss weapon.

Soviet Space Plans Spelled Out

From the various statements by Soviet officials and scientists, particularly from Academician Eugene K. Fedorov, chairman of the IGY's Soviet committee for rocket and satellite research, and his associate I. P. Bardin, we glean the following items regarding the artificial Soviet satellite to be launched into outer space:

There will be several such satellites, of varying weights and sizes, but the average diameter will be about 18 inches.

Each satellite will be launched at a slight angle to the meridian. Its speed will be 18,000 miles an hour. It will complete its circle of the globe in about 90 minutes. Its orbit will cover almost the entire globe. It will travel near but not over the Arctic and the Antarctic.

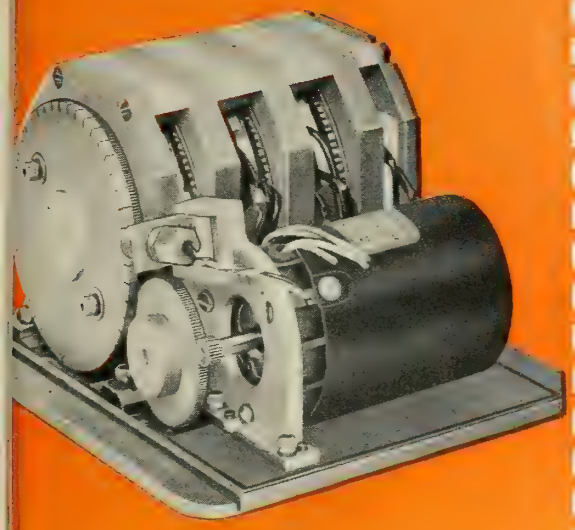
Aboard the best of their satellites the Soviets will install equipment to measure the air's density; the number and energy of micrometeorites; the composition and energy of cosmic rays, electrons, gamma rays, and rays causing the Northern lights. Radio-television will automatically relay this data to the earth.

Since relay energy on some of the satellites will be limited, the information will be signalled only at certain intervals.

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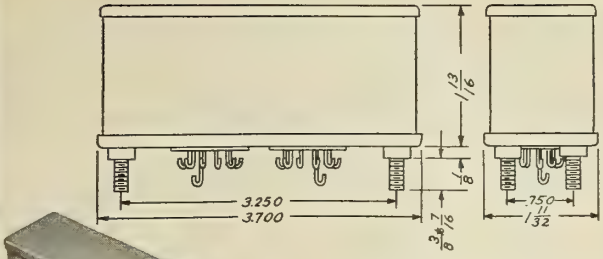
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Russians Study Cosmic Medicine

Cosmic medicine, Russians explain, is that new branch of aviation medicine which deals with the effects of heights and speeds upon man in his future rocket flights. A recent issue of *Sovetskaya Aviatsia* devotes an article on this subject by V. Malkin, described as "candidate of the medical sciences," a physician with an advanced degree.

Having ascended to a great height and having overcome the force of the earth's gravity, a rocket will "come out to its cosmic trajectory, its motors will cease their work," and its astronautic personnel "will find themselves in a state of imponderability, that is, without weight," writes Dr. Malkin.

Already now, the Soviet physician points out, in experimental flights within the limits of the stratosphere it is possible to create these conditions for a period of two to three minutes. This is because in such flights "made along a parabola" the centrifugal force for a time balances the force of the earth's gravity. Experiments with aviators have already shown that some men can successfully withstand the effect.

Several tests have been conducted where the pilot experienced the condition of weightlessness for several seconds.

Red Rockets for Venus

Russian scientists expect to send unmanned rockets to Venus within the next ten years. Instruments in the rockets, according to Radio Moscow, will record photographs of the planet's surface before it lands in order to prove or disprove the existence of life on the planet.

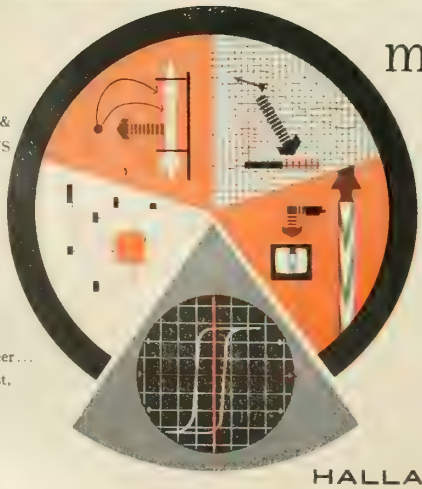
To ponder the question of what plants and other low forms of life may or do exist on Mars and other planets involves no idle theorizing, say the Soviets. Such discussion has a highly practical relevance since we are on the threshold of journeys to those planets and our interplanetary travelers of the bright tomorrow must indeed know what life, if any, they may encounter on Mars, Jupiter, Saturn, and Uranus and whether they themselves can survive there on landing.

This is the opinion of Professor G. A. Tikhov of the Alma-Ata Observatory in the Soviet Kazakhstan in Central Asia, in charge of the Astrobotany Sector of the Kazakh Academy of Sciences. He reveals that "one of the basic conclusions of our observations is that Mars does have plant-life, which circumstance we can announce with sufficient certainty."



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World Astronautics

By Frederick C. Durant III

A number of member societies of the International Astronautical Federation have local sections in various parts of their country. At last count the ARS has 31. The DGRR of Stuttgart has branches in Baden-Wurtemberg, Berlin, Hamburg, Hannover-Niedersachsen, Hessen, Nordbayern, Nordheim-Westfalen, Oberbayern, Saarland and East Germany. The British Interplanetary Society has 5 sections: Midlands, North-Western, Scottish, Western and Yorkshire. The Palskie Towarzystwo Astronauticzne of Warsaw has sections in Cracow, Wrocaw, Bydgoszcz and Katowice. At last report the Yugoslav Astronautico Drustvo based in Belgrade has a branch in Zagreb with groups forming in Sarajevo, Skopje and Ljubljana.

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The DAR rocket group of Bremen has announced plans for a fifth anniversary celebration 27-29 September. The firing of solid propellant oil-spray rockets (m/r April '57, p. 88) will be a feature of the program.

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The German Museum of Munich is reestablishing an Aviation Wing and is searching for historical material. The search is on to locate rocket weapons captured by the Allies which might be made available for display. The remarkable rocketry achievements of the Germans during World War II represent a significant period in the evolution of astronautics. It seems appropriate that technical evidence of this historic work be assembled for posterity.

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Correspondence and contacts in Korea, Greece, Rumania, India and Pakistan indicate interest and a desire to organize astronautical societies in these countries.

•

Academician Leonid I. Sedov, President of The Commission of Astronautics of The Academy of Sciences, Moscow, attended the Third Symposium on Cosmical Gas Dynamics at Cambridge, Mass., recently.

•

A few years back it was possible to add to one's library every new book pertaining to rockets and space flight without straining the pocketbook. Such is no longer the case. Recent publications, however, include some musts. Willy Ley's *Rockets, Missiles & Space Travel* (Viking Press) has appeared in a new edition, enlarged and updated. As a reference work it has no peer.

•

Criterion Books has just published *Man Among the Stars* by German science writer Wolfgang Mueller, translated from his successful *Du Wirst die Erde sehn als Stern*. Mueller is not hesitant to contemplate upon historical trends, psychology, religion and philosophy and their relationship to astronautics.

•

The Navy officially opened the U.S. portion of International Geophysical Year by firing a *Dan* rocket to an altitude of approximately 75 miles from the San Nicholas Island facility of their Air Missile Test Center, Point Mugu, California. The rocket, one of 14 to be fired during the next few months, is equipped with 20 pounds of instrumentation for the study of Lyman alpha radiation, "soft" X-rays of one to two Angstroms in magnitude and gamma rays emitted during solar flare periods. It is hoped that the results of the firings, when integrated with other measurements made during the IGY investigations by the 62 cooperating nations, will enable scientists to determine the relationship between solar flares and radio fadeout.

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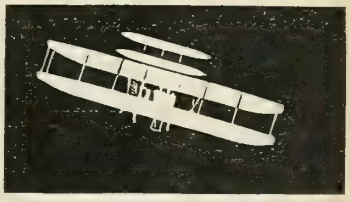
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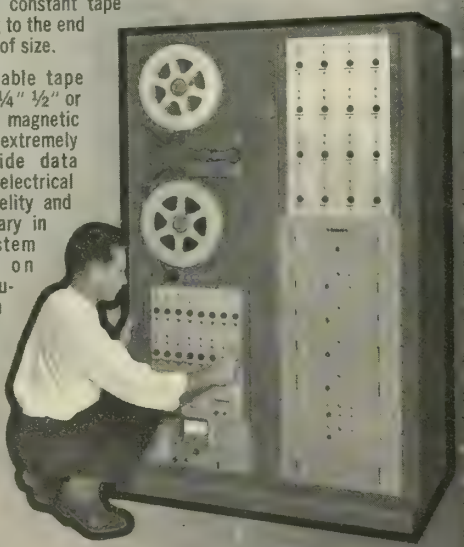
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Three Missiles Produced By French Firm

SNCA du Nord, one of the larger French manufacturers, has given some information on the production status of its missiles. The SS-10, SSM, and the CT-10 target missile are currently in production. The former is designed as an anti-tank weapon. The French company states that it will soon start production of a refined version of the SS-10, the SS-11. Also to go into production is an improved CT-10, the CT-20. The third new production item is the Nord 5103, an AAM. SNCA du Nord expects to receive export orders for its three new production missiles in addition to contracts from the French government.

For its expanded production program, SNCA du Nord will enlarge its facilities at Bourges and will hire more staff. The company at present employs a staff of 8000 at its four plants—Bourges, Les Mureaux, Meaulte and Chatillon.

SNCA du Nord's reports give no details of future projects other than mentioning the fostering of "important developments" and the "confirmation of the future of the company in the field of missiles."

The company regrets that its Gerfaut and Griffon experimental aircraft are not to go into production but it stresses that the experience obtained with ramjets due to use of these aircraft will be useful in the development of future missiles.

Animal Experiments Announced by USSR

Experiments with small animals sent up in rockets (dogs in the Soviet Union, monkeys and mice in the U.S.) have already yielded much valuable data on the physical state of the animals when the latter became "non-weight" for a few seconds or minutes. The rockets' automatic equipment gave doctors the information they needed on the animals' breathing, blood pressure and heart behavior.

Dr. Malkin declares that each such animal's "vestibular apparatus, that is, the nervous system signaling to the central nervous system about the body's position in space," was substantially disturbed in its functions and thus played an important role in the disorientation of the animal while in rocket flight.

But the most worthwhile experiments so far in "cosmic medicine" involve man's imponderability or non-weight status. Dr. Malkin writes of 16 aviators achieving this non-weight condition during a special experimental flight, for 30 to 45 seconds at a time.



Behind the Curtain

By Dr. Albert Parry

One fact above all others is apparent from the latest Kremlin shakeup: Without Zhukov and the other marshals standing behind him, Khrushchev could not have won. However, Zhukov strengthened the political role of the Soviet armed forces even more than he consolidated Khrushchev's power and policies. The Soviet military may not want war, but they certainly want more "diverse atomic and hydrogen weapons, powerful rocket and jet armament of various kinds, including long-range rockets."

But Soviet *talk* of peace is always with us. The current Sixth Five-Year Plan, 1956-60, calls for "a considerable expansion of titanium production"—for peaceful aims only.

Comrade F. Kharakhorin in the Moscow *Trud* presented an article with the significant title; "Titanium, the Metal of the Future." He declared that the USSR's titanium industry has been created comparatively recently, since World War II. "From the carbide of titanium and wolfram, with the addition of metalic cobalt, alloys are obtained whose hardness is nearly that of diamonds. These remarkable materials for cutting instruments are being prepared at the Moscow Combinat of Hard Alloys."

Yet, fangs are bared from time to time in no uncertain manner. The very day that Danish Defense Minister Paul Hansen announced in Parliament that Denmark had accepted the American offer of *Nike* and *Honest John* guided missiles, as part of the joint defense aid program, and that the Danes would be given U.S. missile training, radio Moscow blared (in English) that something was rotten in the capitalistic Kingdom of Denmark also, that Denmark was creating "a grave menace" for herself by accepting U.S. guided missiles, and that the future might bring upon Denmark "the retaliatory blows meant for an aggressor."

Krokodil, Moscow's humor magazine, attacks a Florida travel bureau for running an ad in the *Miami Herald* announcing "sale of tourist tickets for the moon, Mars and Saturn, first such flight now planned for 1987." The Red satire periodical, accuses the Florida concern of "profiteering". But it also argues that the 150 Americans who responded to the ad must have been attracted by the promise that "no passports will be required . . .

Red Prague officially announces its gratification that "the U.S. has chosen a star map made by Dr. A. Becvar of Czechoslovakia for recording the position of its satellites."

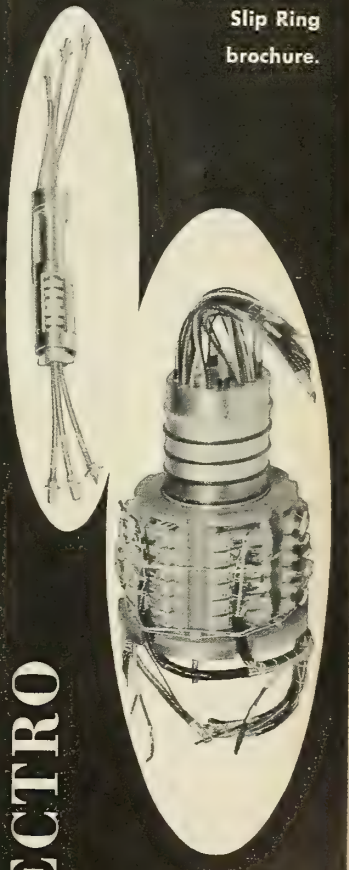
The Czech government also claims a geophysical laboratory some 4500 feet below ground (in a mining pit at Brezove Hory), believed to be the deepest observatory in the world. It is equipped to register movements of the earth's crust caused by the force of gravity of the moon and the sun. The depth provides freedom from surface disturbances.

An electronic computer of the Soviet Academy of Sciences "can click out in a day or a week that which a hundred mathematicians can solve only in a year." This is revealed by V. Safonov in recent issue of the Moscow *Literaturnaya Gazeta.* He adds, however, that it is used only to some 20 per cent of its capacity. The other 80 per cent of the wonderful electronic brain remains idle until Red rocket men have more theories for the machine to test and new tasks to perform.

The Soviets are now considering the proposal of some of their astronautic scientists to reorganize the Lesgaft Natural Science Institute in Leningrad into the Institute of Cosmo-Biology, to study "all problems connected with a possible development of life on other planets, also with conditions of human existence in and en route to such worlds."

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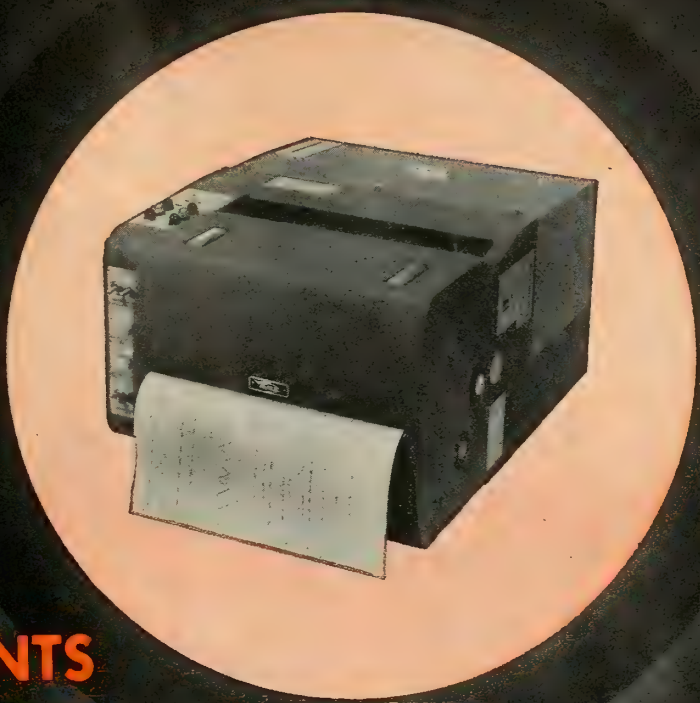
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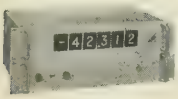
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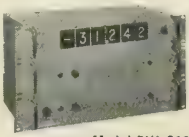
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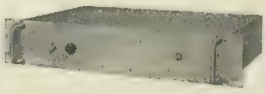
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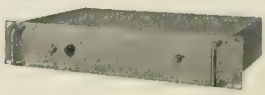
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Washington Spotlight

By Henry T. Simmons

Cancellation of the North American *Navaho* program last month came as no surprise to those familiar with the Air Force's financial plight. The strictures on USAF spending dictated elimination of a major project and military logic did the rest. *Navaho* was mousetrapped between the Northrop turbojet *Snark*, which should be operational by 1959 and the intercontinental ballistic missile which *may* be operational by the early 1960's. The decision may be a wise gamble, but few would argue that it is a comfortable one. It means the U.S. won't have a supersonic intercontinental missile delivery capability until the ICBM materializes—and that, unhappily, may be long after the arrival date now scheduled.

•

The *Navaho* flight test program was plagued by an unusual share of bad luck. Four XSM-64 test vehicles have been fired from Patrick AFB, Fla., since last December and all failed. No. 1 aborted because of the failure of a rate control gyro; No. 2 tore away part of its launching apparatus, lost booster thrust and failed to ignite its ramjets; No. 3 burned up when the boosters quit inexplicably after a couple of seconds. On the fourth and last attempt in June, the booster motors fired for 42 seconds and then quit. Though the vehicle was traveling at an estimated velocity of Mach 1.6, this still wasn't fast enough to light off the big Curtiss-Wright ramjets.

•

Additional firings of *Navaho* test vehicles may be authorized by the Air Force for research purposes if costs can be held down. It is understood that North American has about 12 more XSM-64's in various stages of completion. Assuming NAA can lick the premature stoppage of its booster motors and accelerate the vehicles to the ramjet ignition point, the remaining XSM-64's could provide valuable data on the behavior of large ramjets under true environmental conditions.

•

Loss of the *Navaho* program means that Rocketdyne has no home for the three-barrel, 400,000-pound-thrust booster it has developed for the SM-64 production *Navaho*. The powerplant has been described as extremely reliable in static tests. NAA may propose that the engine be used in the first stage of a souped-up *Titan*, replacing the 300,000-pound motor Aerojet is developing for that purpose.

•

On its first flight in June, the *Atlas* ICBM test vehicle reportedly maintained structural integrity under stresses ranging up to 22 g's. The stresses occurred during the two loops the rocket performed after fuel starvation shut off one of the two motors. The Air Force is understandably pleased by the performance because the structure of the bird has been pared to the limit to insure maximum mass ratio. Example: it must be pressurized during transport to prevent distortion of the fuel tanks.

•

The Navy's decision to settle on a solid-propellant motor for its air-to-surface *Corvus* missile reportedly dealt the death blow to USAF interest in the project. The airmen aren't satisfied with the range of the Navy version, and they see no growth capability in the solid-propellant configuration.

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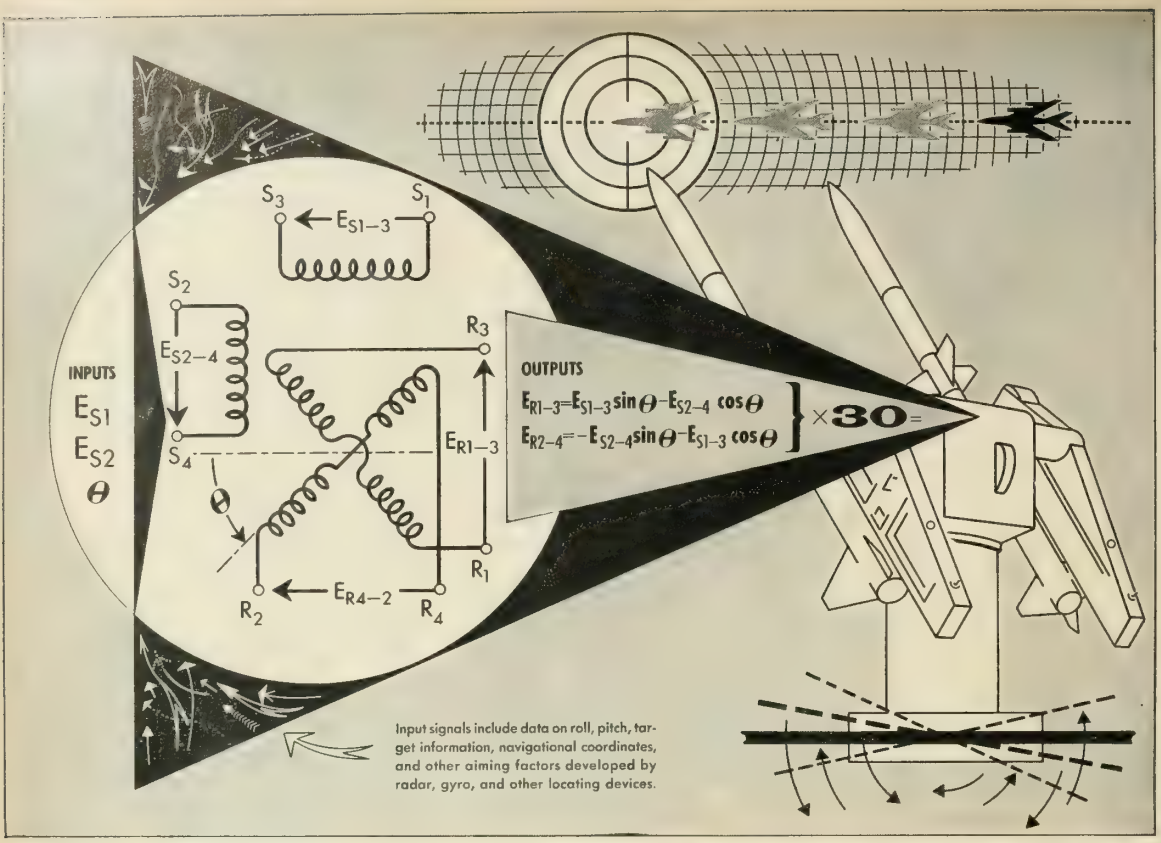
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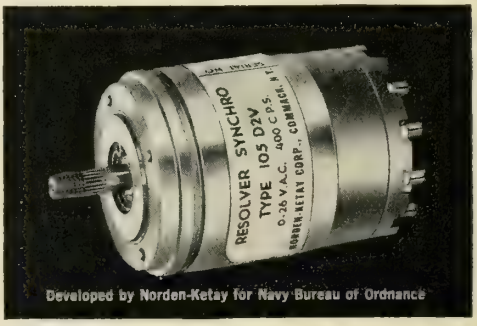
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VOL. 2 NO. 8

AUGUST, 1957

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

m/r exclusive:

Solid Fuel Industry Round-up

By the Editors of m/r

IN 1936 AN INFORMAL group, headed by Dr. Theodore von Karman, was formed at the California Institute of Technology (GALCIT Project) for research on rockets. Modest solid propellant work was undertaken. Two years later, in December 1938, General H. H. Arnold, Commanding General of the then Army Air Corps, asked Cal Tech to come up with a program to develop rockets for boosting aircraft.

It was not until July, 1939, however, that the program got underway at Cal Tech under National Academy of Science sponsorship. The Army Air Corps assumed sponsorship in July, 1940. By 1941, a successful solid RATO (rocket assisted takeoff) was demonstrated and the Aerojet Corp. (under Andrew Haley) was formed to produce the solid rockets. In 1943, the ORDCIT Project was launched to develop long-range rocket missiles. Also in 1943, the US Naval Ordnance Test Station at China Lake, Calif. was established (at a cost of over $100 million).

Under OSRD some $100 million was spent on various rocket projects during World War II. These projects developed such solid rockets as the Bazooka, a full line of aircraft and artillery rockets, the *Privates A* and *F*, and the large *Tiny Tim* 11.75-in. aircraft rocket. In 1946, the Jet Propulsion Laboratory was established at Pasadena at a cost of about $3 million.

From these humble beginnings has grown a vast solid propellant framework of governmental agencies (Table 1) and an industrial and research team (Table 8). From the original Aerojet group there are now over a dozen private companies engaged in various phases of solid propellant rocket activity. Most are under ten years old—and the average is nearer five years. A run-down on the latest activities of the industry-research team follows.

Solid Rundown

AEROJET-GENERAL: Now a subsidiary of General Tire & Rubber, Aerojet now accounts for 40-50% of revenue. Latest developments: A static firing of Polaris; lowering of RATO cost to under $200 each for a one thousand pound thrust, 15 sec unit; also, development of a low-cost ammonium nitrate solid propellant using oil-extended synthetic rubber fuel-binder. Present standard binders are believed to be polyester (Aeroplex) base. President is Dan C. Kimball, former Navy Secretary.

AMERICAN ROCKET: Formed in 1954, this group is active in all types of composite solids. Has specialized in gas generators and auxiliary power units but now said to be working on primary sustainer. Operated under Alfred J. Zaehringer with extensive experience in solids.

ATLANTIC RESEARCH: Since Korea, Atlantic has continued to expand its Navy-built rocket facility. Engaged in development of *Iris* and *Arcon* sounding rockets. Basis of propellants may be polymer-type (viz., epoxy, polyurethane, or vinyl). Headed by Arch C. Scurlock, strong in combustion field and V. P. Arthur W. Sloan, organic chemist.

ARMOUR RESEARCH: Has one group devoted to solid propellant research. Armour has played an active role in the development of rocket artillery—particularly the rocket gun.

EXPERIMENT, INC.: Also a research group, Experiment's work has been concentrated in problems involving the combustion of solids.

GRAND CENTRAL: Originating around Korea, GC has been divorced from its parent Grand Central Aircraft. Activities include production of *Dart, Wasp,* and *Asp* solid propellant rockets. Seems to be centered in composites. Working on third-stage Vanguard rocket using composite propellant plus conventional metal hardware. Headed by former JPL man, Charles E. Bartley, a staunch low-cost solid propellant advocate.

HERCULES POWDER CO.: Hercules Powder has operated the Allegany Ballistics Laboratory since World War II. Operations seem to be built around double-base solids. It is also now working on a third-stage *Vanguard* rocket but using a high-energy homogeneous propellant and plastic hardware. Also produces *Honest John* propellant and a RATO unit.

JET PROPULSION LABORATORY: Still a strong research and development influence in the solid field, JPL has advanced the concepts of large solid propellant rockets through its *Sergeant* design.

OLIN MATHIESON: Prior to present

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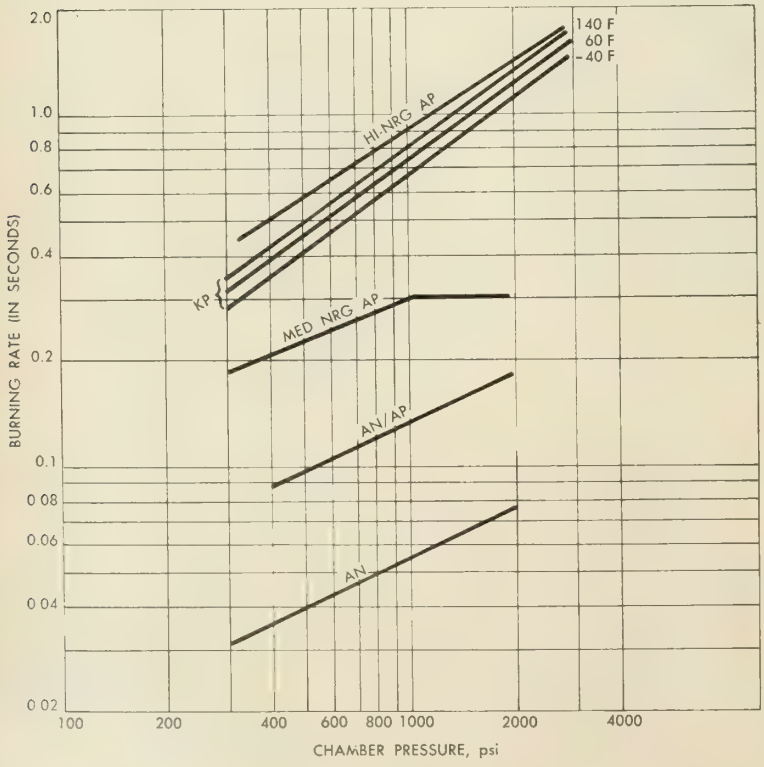
During the past ten years solid propellants have come up fast performance-wise. A great deal of expansion, scale-up, and consolidation is now taking place. In this issue, m/r presents for the first time an exclusive and complete roundup of the US solid propellant picture. This is another in a series of m/r special services to industry.

*

Table 1

Governmental Solid Propellant Activities

AGENCY	LOCATION	ACTIVITY
Air Force		
Armament Center	Eglin AFB, Fla.	Aircraft Rockets
Flight Test Center	Edwards AFB, Calif.	Testing (w/aircraft)
Holloman ADC	Alamogordo, N. M.	Testing
Missile Test Center	Cocoa, Fla.	Testing
Wright ADC	Dayton, Ohio	Propellant evaluation
Army		
Ballistics Research Lab.	Aberdeen, Md.	Prop. evaluation & testing
Chemical Center	Edgewood, Md.	Gas generators
Frankford Arsenal	Philadelphia, Pa.	Gas generators
Ordnance Ammunition Cmd.	Joliet, Ill.	Rocket guns
Picatinny Arsenal	Dover, N. J.	R&D, production & testing
Redstone Arsenal	Huntsville, Ala.	R&D
Rock Island Arsenal	Rock Island, Ill.	Testing
White Sands Proving Ground	White Sands, N. M.	Testing
NACA		
Lewis Flight Propulsion Lab.	Cleveland, Ohio	Propellant evaluation
Pilotless Aircraft Res. Sta.	Wallops Island, Va.	Booster testing
Navy		
Missile Test Center	Point Mugu, Calif.	Testing
Ordnance Test Station	Inyokern, Calif.	R&D, production & testing
Powder Factory	Indian Head, Md.	R&D, production & testing
Proving Ground	Dahlgren, Va.	Testing



Graph illustrates the performance characteristics of some better known solid oxidants.

merged firm, Olin industries under John Olin had developed considerable experience in homogeneous propellants for guns. After World War II, this experience was put to work in rocket field. Largest unclassified solid propellant activity is devoted to turbojet starters and cartridge actuated devices.

PHILLIPS PETROLEUM CO.: Entering the ammonium nitrate propellant field around Korea, Phillips now operates the large Air Force Plant No. 66 and is engaged in production of the M15 RATO and large booster rockets.

PROPELLEX CHEMICAL: Newest entry into the solid propellant field is headed by Dr. Robert A. Cooley who formerly headed double base rocket propellant operations for Olin Mathieson after World War II. Formed last year, Propellex will produce double base and composite propellants.

ROHM & HAAS: The Redstone Division is devoted to research and development of high-energy double base propellants.

REACTION MOTORS: Formerly all-liquid, RMI has recently turned to research and development of solid systems.

SOUTHWEST RESEARCH INSTITUTE: The SWRI solid propellant work has been headed toward research and development of industrial uses of solids.

STANDARD OIL CO. (IND.): Entered the ammonium nitrate solid field around Korea, this operation is headed by Wayne A. Proell. Now in production of S12 cartridge starters and other solid rockets.

THIOKOL CHEMICAL CORP.: Entered the rocket field around 1948. Rocket groups are headed by Harry Ferguson with technical head Harold W. Ritchey—cogent believer of large solid rockets. Thiokol's far-flung rocket empire now accounts for ¼-½ of company revenue. Employs composites using own polysulfide fuel-binder. Rockets: *Lacrosse, Loki, Falcon, Nike-Hercules,* RV-A-10, and *Sergeant.* Boosters: T-40, T-50, and T-55.

UNIVERSITY OF DETROIT: Formed last year for research, the Missile and Rocket Section is headed by Dr. Donald J. Kenny. Projects solid fuels for ramjets, new high-energy fuels and oxidants.

In addition, there are the offshoots of the rocket field (Table 3) whose services are required for solid propellants—viz., squibs, igniters, and rocket pyrotechnics.

Today and Tomorrow

During all of World War II, nearly $0.75 billion was spent on research, development, and production of solid propellant rockets. Since that

time a conservative estimate is that at least that much has been spent during the ten years following the war. Of this latter amount, about 75% was spent during the Korean affair. At the present time nearly $100 million per year is going into raw materials for solids, research and development, hardware, and production. At the present rate of expansion, the solid propellant industry will be worth about $250 million per year within the next five years.

It is hard to derive an employment figure for the solid rocket industry. Much smaller forces are employed than the talent being poured into the liquid business. Estimates place the employment at between 50,000 and 100,000 total if one includes all hardware, engineering, administrative, and supporting personnel. One thing is certain, however. The solid propellant industry, despite the hazards, is far safer than virtually any other industry. Figures just published by the Bureau of Labor Statistics give the overall industrial injury frequency rate as 11.1 per million man-hours. The figure for the explosives field (which takes in solids) is 2.4. Only synthetic fibers had a lower rate (2.3).

With an environment like this, the solid propellant industry cannot help growing into a new influence in this rocket age.

Solids Selling

During the past ten years solid propellants have made a great deal of progress from the specific impulse of gunpowder at about 50 seconds to near 250 seconds with the new high-energy composite solids. This progress has been made without much fanfare or ballyhoo. Indeed, so quiet has been the transition that only a few are aware of the great strides solids have made. Only now is the great operational shift to solids being realized. Probably the most cogent factor in this shift is one of the most outstanding properties of a solid propellant rocket-simplicity. Out of this extreme simplicity has come the reliability which has not yet and may never be achieved by the liquid propellant rocket. In addition, there is now obtainable a performance equal to or better than present liquid rockets. Other important factors are ease in handling and long shelf life.

All of these factors are responsible for solids selling. It is evident in our growing arsenal of missile weapons. In almost every weapons category, solids are occupying a more prominent position.

Solids first invaded the artillery field and have been strong there for about ten years—particularly for short range ballistic weapons. During World War II and the Korean operations, solid rockets were handled by the average GI under the most adverse environmental conditions. Under such battlefield environments, solid rockets gained the reliability of conventional artillery—viz., failures on the order of one in ten to a hundred thousand. The range of such artillery rockets has been constantly expanding so that *Dart, Little John, Lacrosse,* and *Honest John* have given the battlefield commander a depth of operation of about 20 miles by these simple weapons. Now, the solid *Sergeant* is about to replace the operationally complex and awkward liquid *Corporal* to give a span of about 50 miles. This, however, is not the stopping point. Already the solid *Polaris* its beginning to have its effect on the

Table 2

Hardware on the Shelf: RATO's, Boosters, and Sustainers

Name	Time (Sec)	Thrust (lb.)	Impulse (lb. sec)	Overall Length (in)	Diam. (in)	Loaded wt. (lb)	Ford (lb)	Mfr.	Prop.	Notes
1.0KS-10,000	1	10,000	10,000					A	KPC	Firebee Booster
1.8KS-7,800	1-8	7,800						A	C	Booster
2.KS-36,250	2	36,250						A	C	Booster
2.2KS-33,000	2.2	33,000						A	C	Regulus I Booster Canted Nozzle
2.5KS-18,000	2.5	18,000						A	C	Cost $515 ea.
3.5DS-5,700	3.5	5,700		110		155	55	H	DB	"Deacon" I sp = 196 Cost = $2,500 ea.
4KS-8,000	4	8,000						A		Booster
5KS-4,500	5	4,500	22,500	54.6	9.38	236	111	A	APC	Canted Nozzle
12KS-250B	12	250		20	7	55	35	A	APC	"Junior JATO"
14AS-1,000	14	1,000	14,000	35.4	10.25	194	115	A	AKPC	Asphalt propellant
14DS-1,000	14	1,000	14,000					H	DB	Black Smoke
15KS-1,000	15	1,000	15,000	33.4	10.1	144	72	A	APC	Cost $155 ea. CAA certified
M-15	16	1,000						P	ANC	Formerly T-60 Operation = 65th 160F
Pusher				175	24			P	ANC	Smart Sled prop. Possible Bomarc booster
RV-A-10				180-192	15-20			T	PSC	Hermes motor
T-40				54				T	PSC	Artillery rocket
T-50	2.36-2.50	53,000						T	PSC	Matador Booster
T-55				37.5		61.5	26	T	PSC	Booster
T-56	14	1,000						H	DB	Glass-reinf plastic bottle by Fairchild
T-131								?	?	Spin stab. 2.75" Mighty Mouse gun launched
X-90	90							AR	ANC	Sustainer
X-300								AR	ANC	Sustainer
S-12								SOI	ANC	Cartridge Starter for B-57

A = Aerojet-General
H = Hercules Powder
P = Phillips Petroleum
T = Thiokol
AR = American Rocket
SOI = Standard Oil (Ind.)
KP = Potassium Perchlorate
AP = Ammonium Perchlorate
A = Asphalt
PS = Polysulfide
AN = Ammonium Nitrate
C = Composite
DB = Double Base

Table 3

Squibs, Igniters and Rocket Pyrotechnics

COMPANY	LOCATION	PRODUCT
Atlas Powder Co.	Wilmington, Del.	Squibs
Bermite Powder Co.	Saugus, Calif.	Igniters, Black Powder
E. I. duPont deNemours & Co.	Wilmington, Del.	Squibs, Black Powder
McCormick Selph Assoc.	Hollister, Calif.	Squibs, Igniters
Hercules Powder Co.	Wilmington, Del.	Squibs
Metal & Thermit Co.	E. Chicago, Ind.	Pryotechnics
National Northern Co.	W. Hanover, Mass.	Squibs, Pyrotechnics

Table 4

Solid Propellant Ballistics

Propellant	Burning Rate @ 1000 psi (70 F)	n	Temperature Sensitivity	Combustion Temp. (°F)	Density g/cc	ISP (Sec.)
Cordite (SU/K)	0.50	0.71	High	3800 (@ 350 psi)	1.6	14J @ 350 psi 195 @ 2000 psi
Ballistite (JPN)	0.65	0.69	High	5300	1.7	200-205
Black Powder	....	....	Low	4000	1.2-1.9	40-80
Galcit (Asphalt)	1.4	0.75	Medium	4000-4500	1.8	176
KCL04-Aeroplex	0.74	0.71	Medium	.....	.....	180-190
NH4CL04-Aeroplex	0.3-0.9	0.5-0.6	Low	4000-4500	.....	210
NH4N03-Aeroplex	0.055	0.5	Low	.....	.....	.....

long range rockets, *Redstone, Jupiter,* and *Thor.* Next will come a solid propellant ICBM!

Even as reliable as solids are today, the reliability picture is constantly improving. This improvement comes as a result of using well established ordnance techniques plus bringing in the latest in quality control and inspection. Solids in the RATO field have achieved an enviable reliability record: a failure of about five in one million! The reason is simple—what can go wrong in a system unburdened by plumbing, valves, controls, and containing no moving mechanical parts? For all the bugs have been ironed out in a research and development program aided by constant firings in static and dynamic tests. Obviously this results in costly development (probably no more costly than a liquid program) but the payoff comes in a superior operational product whose characteristics are well defined. For one shot operation, solids, despite their higher apparent cost, are actually cheaper. And, interestingly, the liquid people only hope to have achieved a reliability of 98% in the next ten years. Compare this to the reliability of 99.995% already attained by the average solid propellant artillery rocket or the 99.9995% attained by solid RATO.

Of course, solids have long been selling for aircraft rockets. The solid *Mighty Mouse* has done for rockets what bullets have done for guns. The larger *Falcon* is now further increasing the punch of the interceptor as is the *Sidewinder* and the *Sparrow.* The solid *Nike-Hercules* and the *Hawk* are beginning to invade the ground-to-air field. It is interesting to note that a solid propellant booster is being considered for the *Bomarc* and that an advanced solid propellant ramjet for long-range AA is in the works.

Now that unexcelled reliability and performance comparable to liquids have been achieved, three barriers (now largely mental blocks in the minds of engineers) are systematically being dis-



solved by the solid propellant industry. These so-called barriers are control, repeated operation, and cost.

The matter of control is believed to be receiving major attention. By control is meant on-off operation or throttability. Solid rockets can now be built in almost any size—even to the ICBM or larger. However, ways and means must be sought to make corrections to the pre-programmed systems of present solid propellant rockets. This is now thought to be capable of solution by design of a pre-program which will take care of most flight situations and then using smaller auxiliary rockets for corrections. Such systems are already well advanced concepts in the *Honest John*, the X-17, and the forthcoming *Vanguard*. On-off solid propellant operations for a number of cycles has already been accomplished. Efforts toward throttling solid motors have been directed toward the lines of a solid-liquid motor. However, what has been gained in throttling appears to be lost in reliability.

It is true that most solid propellant motors have been designed for one-shot operation and for most situations this has been perfectly satisfactory. However, there are many situations where recovery and repeat operation are desirable. Here solids are making an inroad through cartridge actuated devices. It is now perfectly feasible to design a large solid propellant rocket motor which can be fired, reloaded and refired for a number of times much as a gun. Such repeat operation is the key, too, for many commercial and industrial applications of solid propellant power. Within ten years, cartridge devices will have advanced to the point where large power outputs—comparable to internal combustion engines—will be possible.

In the field of costs, two factors are at play. One, as production increases, costs have been coming down. The most significant whack at solid propellant prices have been made by the cast composites—particularly ammonium nitrate types. However, the entire matter of cost is becoming less important as it is realized that solids are doing their good jobs. Despite the fact that you may buy flour, milk, eggs, and yeast cheaper than the final product, few housewives bake their own bread. Thus, a pre-packaged food industry has grown up. Solid propellants will do the same thing for the rocket industry. Here, a completely unitized rocket product, ready to use, a so-called "instant" rocket will be turned out. We are simply equating total cost and the ability to do a given job. Thus, the old engineer's forte that liquid propellants' cost is lower than

Table 5

Solid Oxidants

Material	Available Oxygen, %	Performance (1)	Cost, $/lb	Availability (2)	Exhaust
Ammonium nitrate	19.5	M	0.05-0.10	H	N
Ammonium perchlorate ...	34.2	H	0.50-0.75	L	N,HCl
Nitrocellulose ...	...	M	0.73-1.00	M	C,H,O,N
Nitrogylcerin	...	H	.....	M	C,H,O,N
Potassium perchlorate	46.2	M	0.15	M	KCl

(1): High, over 200 sec
Medium, under 200 sec

(2): High: > 1,000,000 tons/yr
Medium: < 1,000,000 tons/yr
Low: < 1,000,000 lb/yr

Major role played by ammonium nitrate for the past ten years has been based on low cost, high availability. Performance of less than 200 sec I_{sp} is pushing it into the background. Ammonium perchlorate, with high oxygen content and I_{sp} over 200 sec, could be replaced by lithium perchlorate. U.S. production of oxidants currently exceeds the demand. Red China disclosed interest in the solid propellant field by ordering the following chemicals from Britain and Norway: ammonium nitrate, cellulose nitrate, lithium compounds, potassium chlorate, potassium dichromate, potassium nitrate, sodium nitrate, and sodium perchlorate.

One of the outstanding uses of plastics in the missile business is their application as solid fuel-binders. The number of materials available is extensive. Processing system is either thermoplastic or thermosetting although in the case of polyamide both are used. Generally, the fuel value of the plastic is good. Due to great plastic demand for many applications throughout the industry availability is high with costs not excessive. Although costs for plastics are much higher than with metals an increasing demand for the material is expected in the future. New fabrications are constantly being explored.

Table 6

Plastics for Fuel-Binders

Material	System	Physicals	Binding Efficiency	Fuel Value	Processing	Cost	Availability	Exhaust Products Contribution
Acrylic	TP	B	G	G	C	H	M	C,H,O
Cellulosic	TS	F	G	H	C-EX	L	H	C,H,O
Epoxy	TS	B-F	H	F	C	H	L	C,H,O
Phenolic	TS	B-F	H	F	C-EX	L	H	C,H,O,N
Polyamide	TS-TP	F	H	F	C-EX	M	H	C,H,O,N
Polyester	TS	B-F	H	F	C	L	H	C,H,O,
Polyethylene	TP	F	G	G	C-EX	L	H	C,H,O,
Polysulfide	TS	F	H	G	C	H	L	C,H,O,S
Polyurethane	TS	F	H	G	C	H	L-M	C,H,O
Polyvinyl	TP	F	G	F	C	L	H	C,H,Q
Synthetic Rubber	TS	F	G	P	EX-M	L	H	C.H.O (N,O,S)

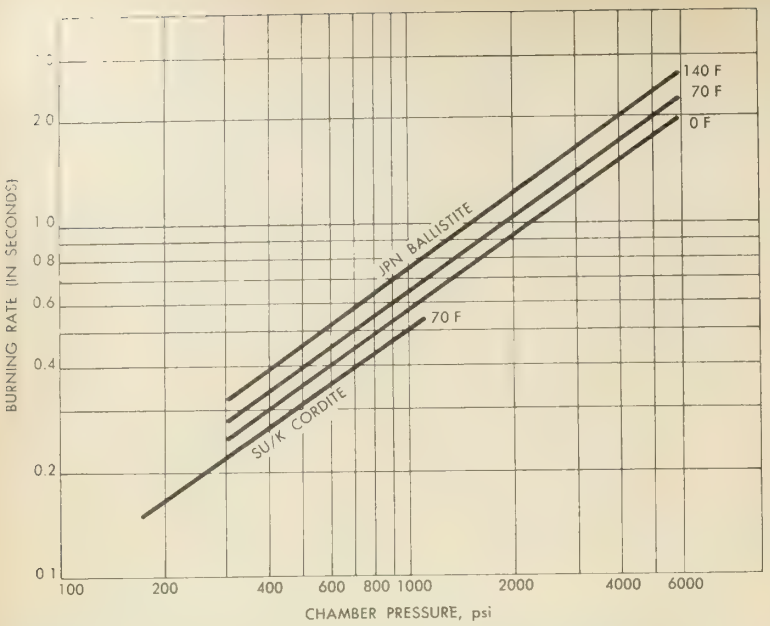
TP: Thermoplastic
TS: Thermosetting

B: Brittle
F: Flexible

L: Low
G: Good

H: High
P: Poor
M: Medium

C: Casting
Ex: Extrusion
M: Milling



Performance comparison between two well known solid grains, JPN Ballistite and SU/K Cordite. High operating pressure and burning rate of Ballistite illustrate favorable performance characteristics. Ballistite is a performance-proven propellant for air-to-air missiles.

solid propellants' cost is fast falling by the wayside. And it has been demonstrated that the propellant cost of a modern missile is only a fraction—2 to 5%—of the total cost. The reasons for a lower delivery cost with solids is, again, due to simplicity. Solid rockets are generally much cheaper to build than a liquid rocket—as much as 50 or 100% cheaper in many cases. Because of the usual higher density of solids (despite somewhat lower specific impulse), solid rockets are much better in performance on a volumetric basis. In field operations, the advantages of a simple, ready-to-go solid rocket are obvious. If your rocket is difficult to service, set-up, and fire, all delivered factory price advantage disappears. And, strategically, all missiles, solid and liquid, are as vulnerable as the factory producing them.

For these reasons, solid rockets will continue to sell. They are, in effect, selling themselves.

The Propellants

Despite the wide range of ballistic performance in the various available propellants, the actual raw materials going into solids is quite limited (Table 7—Production of Solid Propellant Materials and Table 5 Solid Oxidants and Table 6 Plastics for Fuel-Binders).

Although there is a great deal of propellant activity, there is very little available information on modern solids —either composite or double base. Table 4, however, does present ballistic properties for some recent propellant formulations.

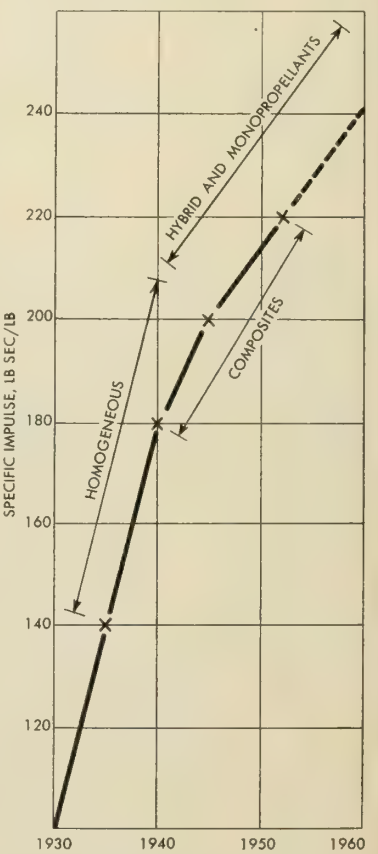
It has been a general axiom in the solid field to keep technology either in the classified or "trade secret" domain. Because of this attitude many applications have fallen by the wayside or have been passed over to the more open liquid propellant rocket industry. In addition to this potential sales loss, the very meager information has caused young engineers coming up the ladder to look to the glamour of liquids. An industry cannot continue healthy growth in such a stifling environment.

Historically, the first break away from old black powder came with the discovery of molecules which contained both oxidant and reductant (fuel) in the same compound. Such materials are nitrocellulose, nitroglycerin, and the newer diethylene glycol dinitrate. Although these and similar materials give high energy releases (performances on the order of 200 sec and to 250 sec in 5 years), stability has been a big problem. Aerojet, Hercules, and Rohm & Haas are working on new solid monopropellant molecules such as the nitropolymers, and nitrated plastics. And, it now appears fairly well certain that only the stability problem will be licked and that getting an I_{sp} of over 250 sec is a long way off.

Therefore, it seemed a matter of expediency to try mixtures of oxidant and fuel to get the desired performance and stability. These composites have achieved a great deal of stability, though perhaps at the cost of specific impulse. Only now is work being directed toward jacking up performance to 250 sec or greater. Under classification, this may already have been achieved, though outwardly composites appear to be hung up at 210-225 levels. with known compounds, getting over the 250 hump may be impossible to achieve in practical systems. Yet basic work is reported on the "weird" or "impossible" compounds which might make new oxidants or fuels. The solid people will have to seriously look at these new developments if they are to compete with the new fluorine or ozone liquid systems.

During the past ten years, ammonium nitrate has played an immense role in lower solid costs and maintaining good performance. It now looks like ammonium perchlorate which has formed the mainstay of our high energy composites may eventually lose ground to lithium perchlorate which is now being advocated. In addition, potassium perchlorate's role as an oxidant will continue on the down-grade.

Another alternative is visualized as the solid-liquid system. Only two such systems have been tried (GE with their



Tremendous rise in specific impulse for solid propellants since 1930 is seen as an outstanding engineering achievement. Composites are currently raising energy release.

hydrogen peroxide-polyethylene and the Pacific Rocket Society with LOX and polysulfide rubber). Netiher of these systems probably reached over 225 and the additional complexity was a definite disadvantage. It is even doubtful if gels, pastes, slurries and the "gunk" combinations can break through the solid impulse plateau.

The Hardware

Since the develoment of the first successful solid RATO there has been a constantly increasing buildup of hardware on the shelf in the form of RATO's, boosters, and sustainers. The accompanying table lists some of the major types now known to exist. In addition, there are available many classified units and rockets which are yet on the design boards.

In addition to better construction methods and improved reliability, the unit costs of such hardware has steadily been coming down. In a recent contract to Aerojet (an order of over twenty thousand ammonium perchloride-Aeroplex units), the familiar 1000-lb RATO dropped in cost to slightly over $160. However, lowering propellant cost on a similar unit (as evidenced from Phillips' ammonium nitrate propellant) has only dropped that figure by about $30. One can thus conclude: that unless solid propellants can be made on a continuous rather than a batch basis or unless an automated propellant plant is possible, labor costs will be the determining cost rather than low materials cost. It is also evident that a large portion of the total rocket cost will be vested in hardware rather than propellant by virtue of labor costs.

As yet the glass-reinforced plastics hardware has yet to make significant inroads into solid motors. Although some rather startling advances can be made (viz., in strength-to-weight ratios), it is also true that costs are much higher than with metals because of more hand operations. Even where machine techniques have been introduced in plastics hardware, there still appears to be too much variation for engineers to contend with. Plastics, though, are definitely here to stay, in the fabrication of solid propellant rocket hardware.

A considerable amount of scale-up has taken place since the "large" *Tiny-Tim* rocket of World War II. The scale-up barrier was first broken by development of the cast composite grains and then was closely followed by solventless cast double base grains. A conservative estimate places the impulse level of today's single grains at about the ½-1 million lb-sec mark. Indeed, it seems likely that several million lb-sec are now possible; this is borne out by the fact that Aerojet is working on a solid IRBM, the *Polaris*. It is not known if this fleet ballistic weapon will be single or multiple-staged. Now, both the double base and the composite manufacturers seem confident enough in possible scale up to say that they have not yet reached an upper size limit. Then, it seems likely that large solid propellant powerplants will first invade the IRBM class and will then follow up with a truly strategic or tactical ICBM. Application of solid propellant power to these weapons will mean that virtually any spot on earth can be used for a base.

Aside from the use of existing solid rockets as boosters or auxiliary power plants for space operations, it is certain that truly solid space rockets will have to wait until the solid IRBM and ICBM has become a reality. It also means that solids are still trailing liquids in the large-scale applications but the gap between the two is constantly drawing closer. When the gap is closed and if solids can overtake and exceed liquids remains for the solid propellant industry to accomplish by hard work.★

Table 7

Production of Solid Propellant Materials

Material	Total US Production 1956 (Short Tons)	Estimate Rocket Use 1956 (Short Tons)
Ammonium nitrate (solid only)	1,000,000	5,000
Ammonium perchlorate	3,600	3,000
Lithium nitrate	5	0.25
Lithium perchlorate	1	0.75
Nitrocellulose	10,000	1,000
Nitroglycerin	2,000	900
Potassium perchlorate	1,000	500

Table 8

The Industry-Research Team

Firm	HQ	R&D	P	T
Aerojet-General Corp.				
Azusa, Calif.	X	X	X	X
Sacramento, Calif.		X	X	X
American Rocket Co.				
Wyandotte, Mich.	X	X	X	
Ypsilanti, Mich				X
Armour Research Foundation				
Chicago, Ill.	X	X		
Joliet, Ill.				X
Atlantic Research Corp.				
Alexandria, Va.	X	X		
Gainesville, Va.			X	X
Experiment, Inc.				
Richmond, Va.	X	X		
Grand Central Rocket Co.				
Redlands, Calif.	X			
Mentone, Calif.	X	X	X	X
Pomona, Calif.				X
Hercules Powder Co. (Allegany Ballistics Lab.)				
Cumberland, Md.	X	X	X	X
Jet Propulsion Laboratory				
Pasadena, Calif.	X	X	X	X
Olin Mathieson Chemical Corp.				
E. Alton, Ill.	X	X	X	X
Phillips Petroleum Co.				
Bartlesville, Okla.	X	X		X
McGregor, Tex.			X	
Propellex Chemical Corp.				
Edwardsville, Ill.	X	X	X	X
Rohm & Haas Co., Redstone Div.	X	X		X
Reaction Motors, Inc.				
Denville, N. J.	X			
Dover, N. J.		X		X
Southwest Research Institute				
San Antonio, Tex.	X	X		X
Standard Oil Co. (Ind.)				
Whiting, Ind.	X	X		
Seymour, Ind.			X	X
Thiokol Chemical Corp.				
Trenton, N. J.	X			
Elkton, Md.		X	X	X
Huntsville, Ala.		X	X	X
Marshall, Tex.		X	X	X
Ogden, Utah			X	X
University of Detroit (Missile & Rocket Section)				
Detroit, Mich.	X	X		
Ann Arbor, Mich.				X

HQ: Headquarters; R&D: Research & Development; P: Production; T: Testing.

MISSILES & MYTHS

The bibliography of missiles, rockets and atomic power embraces the entire known history of mankind. Even the record of primordial man, when we examine what remain of his cave-drawings, indicates the use of some form of missile.

The Talmud and the Christian Bible have innumerable references to missiles and rockets; (Psalms, Proverbs, Epistles etc.) In the Bible we read: that one Ussiah (808-756 BC), ". . . made in Jerusalem, engines invented by cunning men, to be on the towers and upon the bulwarks, to shoot flaming arrows and great stones withal." We may classify these "engines" in two main groups, namely, catapults and ballista, which today are represented by howitzers and guns. (It is interesting to note that our modern word "howitzer" derives from the old Bohemian: "houfnice," a sling.)

We are told that in the 3rd Century BC a certain Dionysius invented the first recorded machine-gun, called "polybolos" or "repeater-thrower," which fired a succession of arrows from a magazine. At about the same time, an Alexandrian engineer, Ctesibius, geared pistons to a catapults arms, "working in carefully wrought cylinders, filled with compressed air."

Plutarch wrote of Archimedes in his Life of Marcellus at the siege of Syracuse, (214-212 BC): "Archimedes soon began to play his engines upon the Romans and their ships, and shot stones of such an enormous size (about 100 pounds), and with so incredible a noise and velocity that nothing could stand before them. The stones overturned and crushed whatever came in their way, and spread terrible disorder through the Roman ranks—at length the Romans were so terrified that if they saw a rope or a beam projecting over the walls they cried out that Archimedes was levelling some missile engine at them, and turned their backs and fled."

The "Atomists" of Democritus (460 BC) developed the theory that all matter is made up of exceedingly small parts, and it is significant that they called such parts "atoms," whence the word found its way into Latin and so down to us.

There exist in many museums in the world, specimens of missile type weapons of the Egyptian Neolithic Age, (circa 3200 BC). Many are in Cairo, Athens, Rome, Berlin, London and some in America. The most interesting are of flint, knapped and chipped with extraordinary care, and some with serrated edges so minute as to be hardly visible to the naked eye. They are believed to have been propelled by bows, throw-sticks, or blow-pipes, and some scientists have theorized that they were given the force of projection by tightly twisting a skein of hair or sinew, prepared in a manner unknown. The missile had a guide stick, often feathered.

What is historically called "Greek-fire" was used as early as the 4th Century BC. It is represented in Assyrian bas-reliefs and graphically described in a record of a siege of Delium (424 BC). Here cauldrons of pitch, sulphur and burning charcoal are shown being hurled against an enemy's position. One Vegetius (350 AD) gives an interesting formula for mixtures of sulphur, naphtha, pitch, incense and tow, all packed in wooden tubes and hurled upon the decks of enemy ships where they ignited.

The Greek-fire idea transformed by modern chemistry, was seen in the two World Wars.

The rocket of the 20th Century is certainly a missile; but it had its genesis in an era before the use of gun-powder. Gun powder had been known to the Chinese long before the 13th Century and had been used both for its fusive and explosive properties. The Chinese first made use of it in a military way by setting off bombs that terrified more by noise and stench than by real destructive power. However, they discovered that rockets could be made that would provide a propellant "going by itself"; instead of advancing from an original position by a sudden force which would decrease to zero, it would increase its speed by self-contained, timed propulsion charges.

A most interesting book by an Arab, Hassan-el-Rammah Nedchureddin, (AD 1280) called "The Book of Fighting," describes a large missile to be used on water. He describes it as two pans containing a pear shaped body filled with naptha, saltpetre and two poles to serve as guides or rudders, and propelled by a series of fuses.

The closest translation from his Arabic text given by an expert is: "a flying egg." If you have ever tossed a flat object over a body of still water and watched it skid in hops, that would seem to partially describe one of the ideas of the Arabian Hassan's missile.

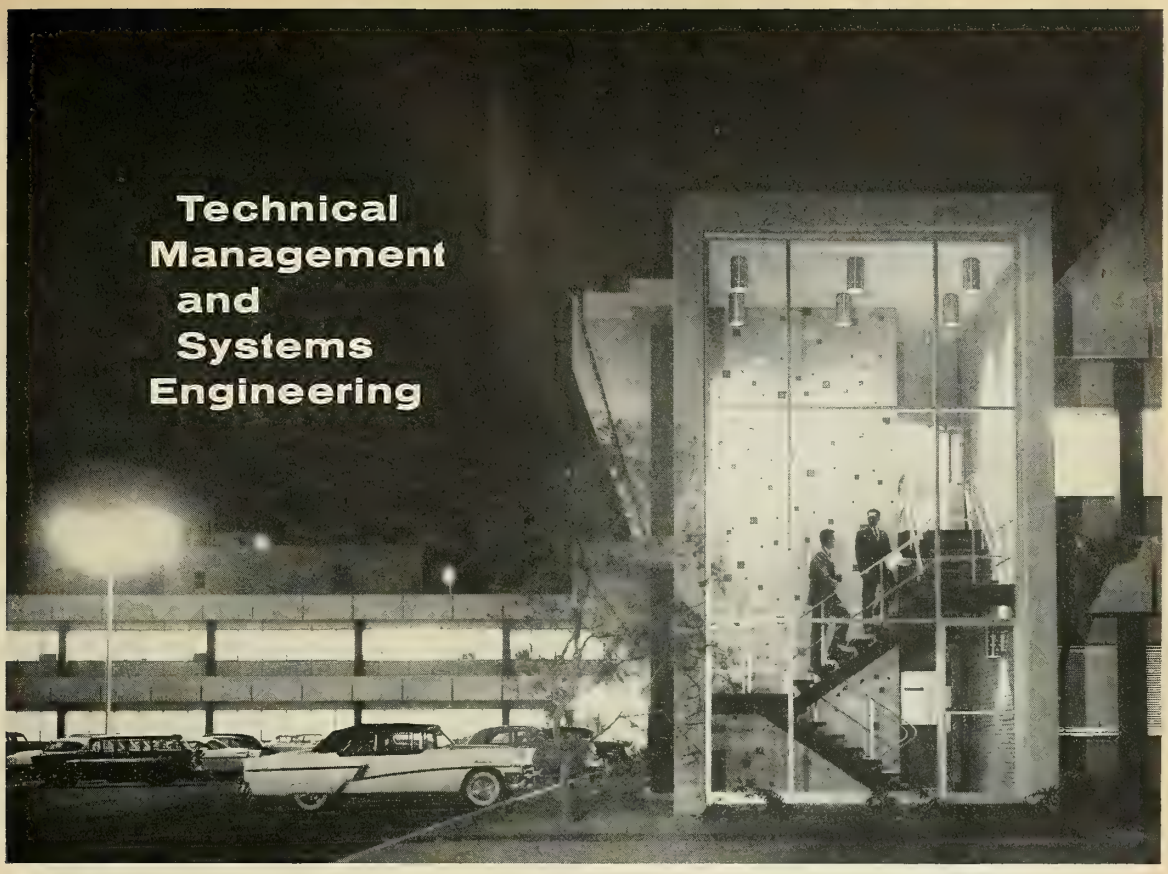
In 54 BC the Britons used hot clay balls as missiles to set fire to Ceasar's camp; (De Bello Gallico, Bk V); in AD 69 igneous missiles were employed in an attack on Placentia; (Tacitus, History Bk II).

During the 12th Century an engine for hurling missiles called a "trebuchet" is recorded as having a projectile force supplied by the gravitation of a heavy weight, rather than twisted cordage as in the catapult and ballista. It is reliably reported that these trebuchets threw other missiles besides stones or flaming arrows; they threw putrid corpses and sometimes live men. A dead horse in the last stages of decomposition, bundled up and shot by a trebuchet into a town in which the defenders were half dead from starvation, started a pestilence. Froissart tells us that John, Duke of Normandy, infected a town this way. Manure, offal and the dead bodies of slain soldiers were used the same way. William of Malmsebury described the Turks at Antioch throwing the heads of slaughtered townsmen into the Frankish Camp. An envoy or messenger was sometimes tied up alive and cast back into the town. (Cowper's Art of Attack.)

The idea of starting a pestilence by use of missiles for such purposes in the 12th Century, seems to have produced an echo in the 20th; until the use of poison and mustard gases, bacteriological warfare and kindred barbaric methods were internationally outlawed. We might ask ourselves if we are any more civilized than the 12th Century generals.

Certainly, our 20th Century has vastly extended the horizons of science and is continuing to fully explore, the illimitable potential science offers for humanity's benefit. Scientists of the world today have justifiable pride in their achievements. Indeed, any study of the history of missiles, rockets and atomic energy by non-scientific people will enhance the respect and appreciation our scientists merit.

Even a cursory reading of the history of missiles and rockets will convince us that there is "Nothing New Under The Sun."



In systems engineering work, it is necessary to bring together a team that includes scientists and engineers of a wide range of technical specialties. In major weapons-systems projects, such teams will include hundreds of scientists and engineers.

But the assembly of a large group of scientists and engineers, no matter how capable they may be individually, does not of itself ensure good systems-engineering performance. The caliber of the project management has a major effect upon its technical accomplishment. It is not easy to coordinate the activities of large numbers of scientists and engineers so as not to stifle their creativeness on the one hand, nor to permit the various development sub-efforts to head toward mutually incompatible objectives on the other.

Of primary importance for good systems management is the philosophy underlying the selection of the supervisory personnel. The head of a technical activity should, first of all, be a competent scientist or engineer. A common mistake — nearly always fatal in systems work — is to fill such positions by non-technical men who have been trained only in management techniques. In the highly complex activities of major systems work, what is required is *technical management*, and of the two words, the word *technical* must never be overlooked.

In the selection of scientists and engineers for technical management, it is essential that the men chosen be broad in their training and approach. Each principal department head, for example, must have a good basic understanding of the technical facts of life of the other departments. When these people get together they need to speak a common language and understand each other's fields, so that proper decisions can be made on the many interrelated problems that come up. The higher the organizational responsibility of a technical manager, the more important this factor becomes.

The Ramo-Wooldridge Corporation is engaged almost entirely in systems work. Because of this, the company has assigned to scientists and engineers more dominant roles in the management and control of the business than is customary or necessary in most industrial organizations.

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Rocket-maker Dan Kimball

Big Future, More Uses for Solid Propellants Liquids to be Limited to Specialty Roles

Former Navy Secretary Dan A. Kimball is one of the top business executives in America's incipient rocket industry. As President of Aerojet-General Corp. he has helped to pioneer many rocket firsts. Here, he outlines a glowing future for solid propellants.

Q. Mr. Kimball, will you tell us a little about Aerojet's role in solid propellants?

A. Actually we're in both the solid and liquid propellants. Aerojet was an outgrowth of the work that Cal Tech did during the war. At that time the only solid propellant we had was the old Smokey JATO unit. We built something like 200,000 of these. We made the first JATO used and the first composite propellant.

Q. Can you say anything about how much of an effort you are putting on solid propellants now compared to liquids?

A. At the present time our dollar sales in liquids engines are much ahead of the solid because of work on the ICBM, *Vanguard* engines and *Bomarc* engines. Also on the number of auxiliary powerplants. On the other hand our development work is more on solids. We've got roughly 10,000 people. We've got almost 5000 working on liquids. We've got about 3000 on solids altogether and the balance is covered with our underwater, avionics, architect and engineering divisions.

Q. What do you think the ratio of solid to liquid uses may be five years from now?

A. I think you'll have many more applications for solids. Liquids are going to lend themselves to specialized applications like ICBMs and possibly IRBMs.

Q. Why wouldn't the solid work so well for the ICBM?

A. So far we don't get the specific impulse from solids we get from liquids, but we're catching up. We're getting about 230 on solids and better than 250 on liquids. I would think in the liquid field you'd have the biggest chance for advancements in specific impulse. But when you get into the very high energy liquids you're going to have some compounds that are very difficult to handle. But I think your real growth potential in the liquid field will be for specialized applications. However, we've made some big advances in solids in the last three years.

Q. Are we at a point in solids now where we can start working with additives like borons?

A. Well, I'm no technical man but I don't think you can put zip fuel additives into solids yet.

Q. Do you think the chemical industry, generally speaking, is backing the rocket industry the way they should?

A. Well, I don't think they know what we want. In our case we've got a pretty large chemical department—as large as any group in the western United States. We've got to tell the chemical people what they should be working on although there are a number of chemical companies that are showing increasing interest. A number of people from different chemical companies come to see us at least once a week and I'd say that we visit them once a week in different fields.

Q. Does fluorine get into solid propellants?

A. Fluorine does nothing. We don't know how to put it in yet. We don't even know the uses in liquids, but we do a lot of talking about it.

Q. Do you think future solid propellant missiles can be stored for from five to ten years?

A. I would think that we'd be pretty sure if we stored them for ten years under reasonably controlled conditions. I don't think that you could let the thing cycle from 140° to —100°F. and do that four or five times a year, however.

Q. Going back to the chemical industry again—on the volume of business. In a solid propellant missile, like Honest John how much, in terms of percent of total cost do the propellant raw materials represent?

A. In the JATO unit you've got 180 pounds of which about 100 pounds is raw propellant. On top of that you have the metal parts of the propellant to process. So I'd say about 35%.

Q. Is it true that 60% of money in the missile business goes for electronics gear?

A. I don't know what the overall figures are on electronics costs. I think it depends on how complicated your missile is. I would think it would be about 1/3 powerplants, 1/3 electronics, and 1/3 fabrication and design. That's without the cost of the warhead.

Q. Would you say that a solid propellant Polaris would be less expensive than a liquid propellant Polaris?

A. In production I would think your solid propellant *Polaris* would be a little cheaper.

Q. Would you say that solid propellant missiles, on an overall basis, would be less expensive than liquids?

A. No, I don't think you could put on an overall basis. It all depends on the particular missile. The liquid engine on the *Nike* we built pretty cheaply when we build a lot of them.

Q. Is there a limiting size to solid propellant missiles where the weight of the casing would be fantastic?

A. You have a problem of handling those bigger sizes, of course. They get to weigh quite a lot. Liquids you don't have to load until your missile is on the launching site. With the solids you have to transport them. None of them yet are of a magnitude that would bother you.

Q. What about work on plastic casings?

A. We've done a lot of work on casings in several different fields of plastics and different kinds of steels.

Q. How are we coming on development of a disposal booster for the Nike?

A. I don't know that they have it yet. We haven't got one, I know. But I think more important than a disposable booster is a disposable case. It's theoretically pos-

sible to build one of those cases that will burn themselves up at the end of the run. It's not an easy job. But there are a lot of things you can do if you want to put enough money into it.

Q. Thiokol has mentioned thrust on the order of 300,000 lbs. Is this tops?

A. You've got to realize a rocket's size is a function of impulse, not thrust. We think we've fired the biggest solid propellant rocket yet, but, with the security restrictions we can't be sure.

Q. Would you care to make a size prediction for the next five to ten years?

A. Just tell us what size you want.

Q. Where is the limiting size of a single unit?

A. Well, every time we think we're near a limit then somebody builds a bigger one. This is a function of the specific impulse of the propellant and it keeps going up all the time. You see it isn't only the increase in thrust you want. You've got to have an increase in specific impulse. I think we could build a 2-or-3 or 400,000 lb. thrust solid engine, but without high impulse propellants it wouldn't be efficient. I remember 10 or 12 years ago the Army wanted a 100,000 lb. unit. We produced it in a few days and it blew up in about 1 minute.

Q. Which propellant materials show the greatest promise for the future?

A. You're going to have to find additives to raise specific impulse.

Q. Tomorrow's solid propellant engine, then, will be a truly composite unit?

A. Oh, yes. They're composite now.

Q. Can you say anything about how you're advancing on the Polaris *project?*

A. Well, we've test fired engines about the size that are to be used. You've got to work out your metal techniques and your weights and control your burning so you can stop it when you want to, however.

Q. On that subject, are you working then on powerplants that you can shut off and start again?

A. We don't know how to start them again.

Q. Is there any possibility of combination engines? I was thinking in terms of two things. One where you might have a solid propellant and afterburn with liquids so to speak, or bypass your solid propellant and add ram air.

A. Yes. If you can find a way to use some of the oxygen from the air for certain applications we could cut out the amount of oxidizer we carry in the case and so increase specific impulse. One of the hard things to get is money to invest in the state of the art. Mostly you have to tie your funds to a specific job. Some of the biggest advances we've made is where we've put our own money into the state of the art work and where the services have also seen fit to put some money in with us.

Q. I'd like to talk about production costs. Does yōūr process engineering group—production engineering group—have more or less equal status with your design people when you get to production missiles?

A. Oh sure. One reason that we moved our whole solid production business up to Sacramento is that we have our production people up there, our research and development people, the whole works. When you start to do the development on a new job, the production people are right in there to start, so that the hardware the development people turn out is something we can use later on. If you don't do it that way, then you have a terrific transition period from the development stage to the production stage.

Q. Is extruding of solid propellants more efficient than casting?

A. Well, it all depends on what you want. If you're going to have high volume, and you don't have to have too high a performance you can extrude the thing cheaper than you can cast it. But the cost of extrusion equipment is very high, and when you want to change the size of your unit, then you've got to change your whole set-up. We think the casting is going to be the best overall, particularly if continuous casting can be perfected.

Q. Can we go underwater—your 155 knot torpedo, for example?

A. We're doing a lot of underwater work. We think there's a real future.

Q. In the case of a hydroduct or solid propellant isn't there a noise problem where the self noise would interfere with the sonar gear in the missile?

A. Well, it all depends on how you're going to use the solid propellant. If you're using the propellant for a direct drive you'll have one noise level. If you're using it to run through a turbine, to run a propeller you have another. One advantage solid propellants would have for torpedoes you'd have a longer storage life. Of course with torpedoes you have to have a number of them ready to go anytime you need them.

Q. Do you see any room for liquid propellant underwater?

A. Yes, sure. We've done considerable work on it.

Q. Do you think that the solid propellant underwater engine has more of a future?

A. We think so. Maybe we're wrong, but we think so. We've done some work on hydrogen peroxide; we've done a lot of work on solids; but we think there's a real future for solid propellants in torpedoes.

Q. How fast will tomorrow's underwater missile be?

A. We think we can top 300 knots in operational underwater missiles.★



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SMALL SOLID ROCKETS for Commercial Use

By G. E. Rice

Manager of Commercial JATO Sales
Aerojet-General Corporation



SMALL ROCKET engines for emergency standby use are being installed at a constantly increasing rate in business and airline aircraft. Aerojet-General's pioneering efforts in this field have been instrumental in providing power units with operational performance capabilities. Commercial application appears to offer the greatest immediate civil market.

Business aircraft use of rocket engine standby units has far surpassed use by airlines. The airlines made the first civilian standby application for high altitude operations. The emergency performance margin of solid rocket engines is recognized increasingly by owners of DC-3's *Lodestars, Convairs,* and converted B-25, B-26, PV-1 and PBY aircraft. These engines have been installed in DC-4 and DC-7 aircraft operated by some airlines. Installations for other types of aircraft are being developed.

Aside from very minor modifications required by standby use, the rocket engine currently used is the same 15KS-1000 smokeless JATO which has been widely used by the military as an assist takeoff unit. After satisfactorily passing through exhaustive vibration, temperature and pressure cycling and drop tests, it has received a CAA Engine Type Certificate.

This 15 second duration 1000-lb thrust solid rocket is the only rocket engine that has received certification. However, Aerojet has a smaller 15NS-250 solid rocket engine currently undergoing CAA certification tests. This smaller unit is designed for use on the lighter aircraft, and may be installed singly or in multiples on airplanes from cub-size through the light twin engine class. It is understood that some other manufacturers are giving consideration to CAA certification of solid rocket engines but this far nothing has been announced.

Standby rocket engines are used on civilian aircraft to meet the requirements of takeoff and approach climb with one engine inoperative and landing climb with all engines. Where takeoff runway limitations occur, they may also be used to shorten the required runway by increasing the acceleration

and the rate of climb for earlier clearance of runway obstacles.

They will also provide full thrust within a few tenths of a second to greatly increase the aircraft performance margins to meet any other short duration emergency requirement. Analysis has shown that they offer a potential for application to over 40 per cent of the situations which lead to takeoff, landing or in-flight accidents.

The 15KS-1000 AI rocket engine weighs 144 lbs. and the 15NS-250 unit will weigh about 42 lbs. The rocket engine weights reduce to 72 lbs. and 21 lbs. respectively when expended. Installed weights are about 175 lbs. for the larger engine and 50 lbs. for the smaller one.

An existing CAA interim policy permits an increase in the gross weight of transport category aircraft equal to the weight of the installed rocket engines in all cases where such weight increase will not exceed the structural gross weight limitation.

As an example, a typical DC-3 installation of two 15KS-1000-AI rocket engines weighs 350 lbs. In DC-3s licensed under transport category performance limitations, the gross weight may be increased by 350 lbs. with the rocket engines installed whenever the weight is limited only by CAB takeoff climb requirements.

A proposal for a new Special Civil Air Regulation is now under consideration by the CAB which would provide much greater weight credits and still result in higher emergency acceleration and climb margins. This proposal covers aircraft certificated under CAR 3, 4B, 4a(T), SR406, SR407, and the new turbine powered aircraft regulation. Early action is expected on this regulation and it should serve to greatly stimulate standby rocket engine installations in both airline and business aircraft.

The gross weights of multi-engine aircraft are generally limited by CAR requirements for climb with one engine inoperative. Under this condition, the maximum available thrust is required to maintain level flight.



Convair 240 equipped with 15KS-1000-AI standby motors mounted externally and internally.

The small remainder available for acceleration and climb is known as the "excess thrust." Since the thrust of one standby rocket engine may be equal to several times the normal "excess thrust" with one engine inoperative, the introduction of the rocket engine thrust will result in phenomenal increases in rates of climb or acceleration.

Limitations in the proposed CAR on the amount of standby thrust for which credit may be obtained preclude the possibility of creating a critical performance situation in an airplane equipped with standby rocket engines. Under the philosophy of the proposal, multiple sequenced units will be required to gain the highest weight increase. These units may be ignited simultaneously to produce very high rates of climb or acceleration to meet severe emergencies.

Standby rocket engines may be either submerged in the airframe or mounted externally. In high speed aircraft the submerged installation is generally preferred. However, measurable drag effect has not been found in multiple 15KS-1000-AI standby engines mounted under the center section of several types of low wing airplanes with speeds up to 365 mph. Design criteria for engineering new installations have been prepared and are CAA approved.

Indicative of standby rocket engine value are three otherwise marginal instances in South American high altitude airline operations. In each case a passenger-laden, four engine aircraft was in critical speed range with no opportunity to accelerate with normally available power. Standby thrust accelerated all three airplanes into speed ranges with comfortable safety margins.

Several manufacturers are now contemplating optional factory installations of standby rocket engines. It is believed that in the not too distant future it will be considered quite normal to incorporate such systems in the basic airframe concept, both as a safety factor and to broaden the operating flexibility of the airplane. ★







DC-3 is assisted in takeoff with 15KS-1000-AI standby rocket motor. This unit is the only rocket motor that has received CAA certification.



"AURORA," a recent expression from the brushes of Simpson-Middleman, a team of artists who find their subjects in the world of the natural sciences. "Aurora," they explain, "is a visual statement with equivocal overtones of dawn, the Aurora itself and a hint of a Chimera." Painting courtesy of John Heller Gallery, Inc.

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Propulsion Engineering

By Alfred J. Zaehringer



MORE LOX FOR MISSILES: Air Products is working on two oxygen plants for the government. One is a 20 ton/day unit (cost is $\$1/2$ million), the other is a 5 ton/day unit ($100,000). ARDC has a new 150 ton/day unit installed at Edwards AFB, Calif. Tonnage LOX can now be produced for $5-15/ton.

MORE HELIUM, TOO, will be going into missiles for propellant pressurization, high pressure controls and actuators. By 1960, the missile industry will gulp down some 300 million cubic feet of the gas per year. In 1950, helium output was about 63 million cubic feet a year.

INDICATIVE OF AMERICAN POTASH & CHEMICAL CO.'s role in the missile market: formation of a chemical fuels section. The section will manage sales of boron and lithium chemicals for exotic fuels and ammonium and potassium perchlorate for solid propellants.

CHEAPER EXOTICS ARE ON THE WAY: Price of sodium borohydride—an intermediate for producing Olin Mathieson alkyl borane fuel—is to go down. Cost of OM's HEF-2 fuel was running $5,000/lb. but is expected to drop to about $4-10/lb. in full-scale production. The high energy fuel would enable the B-58, for example, to fly around the world without a refuel.

LATEST EXOTICS: the diammoniate of tetraborane, a stable $B_4H_{10} \cdot 2NH_3$, reported by the University of Michigan; this compound reacts with water to liberate hydrogen and looks interesting for underwater propulsion systems. Meanwhile at Iowa State College, a nitrile has been reacted with a boron hydride to give $B_{10}H_{12} \cdot 2MeCN$.

STATE OF THE ART of propulsion devices for space flight is "highly speculative" at the present time according to Rocketdyne's George Sutton. Liquid propellant rockets now seem our best bet. Atomic rockets might offer two to three times the specific impulse and other performance increases might come from successful storage of free radicals.

BIG BUGABOO IN ETHYLENE OXIDE systems—large amounts of coke in combustors and carbon in the exhaust. Aerojet, for example, gives ETO exhaust products as (all per cent by volume): hydrogen, 9.1; carbon monoxide, 46.6; methane, 38.4; ethane, 2.0; carbon, 3.9. ETO gives a $C^* = 3474$ ft/sec (chamber pressure of 750 psi and $L^* = 1000\text{-}2000$).

ON THE HORIZON: potential replacements for ammonium nitrate oxidants in solid propellants. Present AN catalysts do not give completely smokeless exhausts. Newer oxidants, soon to be attractively priced, will not require messy catalysts and promise greater stability and lower operating pressures.

THE SOLID PROPELLANT PEOPLE have a waste disposal problem, too. All spillage, waste and residue have to be carefully isolated and carried out to a dump for burning or detonation. As a result serious study is being given to "recycling" scrap propellant for use in a new batch.

THE SEPR FIRM has compared the use of hydrogen peroxide and nitric acid oxidant systems with kerosene fuel for use on manned aircraft. Nitric acid won on counts of high density, low cost and ease in handling. With the same fuel, peroxide systems were found to cost about ten times that of an acid system. The French rocket group ran acid in some 14,000 static tests and handled about 3000 metric tons without major trouble. At the same time, six severe accidents occurred in handling only 200 tons of peroxide.

ATOMIC COLEOPTER has been proposed by Helmut Zborowski, of the French BTZ firm. A nuclear rocket motor is suggested for boost while ramjets take over for sustaining cruise. A cylindrical rocket motor is used.

stepped-up interest:

Solid Fuel Missiles for the Army

By John I. Shafer
Jet Propulsion Laboratory
Huntsville, Alabama

THE ARMY has become increasingly interested in solid propellants in recent years because of the significant technical improvements and the distinct logistic advantages they offer for most of the Army's specific needs.

Early in 1945 research on solid propellants was focused on extending the operable temperature range. In time, substitution of a special elastomer or rubber for the asphalt fuel matrix revealed that cartridge charges would perform reliably even at —50° and 160°F. Furthermore, burning was reproducible at very low chamber pressures, so that the combustion chamber could be lightened and overall performance improved.

Ammonium perchlorate, too, had been substituted for potassium perchlorate in certain formulations. Thus, propellant flame temperature was decreased and propellant performance increased. Thrust and pressure were much less sensitive to changes in burning surface or nozzle throat area. Exhaust gases contained no smoke; however, in very humid atmospheres a fog was created in a rocket's wake.

The Ordnance Department, recognizing the need to extend development of the class of propellants and adapt them to production techniques and specific missile applications contracted with Thiokol Chemical Corp. late in 1946 for a broad development program. Facilities for this work were eventually set up at Redstone Arsenal; later a separate production facility with substantial capacity was also established at Longhorn Ordnance Works under Thiokol's management.

About this time, March 1947, JPL experiments were also made using a radically new charge geometry, the internal burning star.

With this design combustion chambers were so well insulated from the flame by the unburned propellant that chilled motors retained their surface frost, even after relatively long static test firings and despite flame temperatures in excess of 4000°F. As a result, rocket motor designs could be based on the room temperature strength of heat-treated alloys. Performance of solid propellant motors again increased significantly.

In separate tests they had also noted that their new rubber-base propellant could be cast into and the charge bonded to the combustion chamber itself. Adhesion occurred automatically during the charge solidification operation following casting.

With the adoption of the internal burning, case-bonded charge, additional benefits were realized:

1) Processing costs were reduced.

2) The charge was fully supported by the motor against pressure and acceleration forces throughout flight.

3) Performance was further improved by eliminating supplemental charge supports and through higher propellant loading density.

4) The relatively rigid propellant charge materially supported the chamber during transport and handling in the field.

Fundamental research was paying off with significant technical gains.

During November 1947 and April 1948, flight tests were made with a small research vehicle to evaluate the rubber-base propellant for large boosters. Accelerations in excess of 100 g demonstrated their applicability; despite a relatively heavy air frame, velocities were greater than 3500 feet per second. This motor, in a slightly shorter length, was pressed into service as the interim propulsion system for the Air Force guided missile *Falcon* through the cooperative efforts of Hughes Aircraft Co., JPL, Thiokol Chemical Corp. and the interested Armed Services.

Significant improvements in propellant and motor performance continue to materialize as a result of the collective, coordinated effort of all agencies working on solid propellants. Today there are alternate propellant formulations, both composite and double-base (nitrocellulose-nitroglycerin), that exhibit competitive performance in large and small motors, so that the country is not dependent on the rubber-perchlorate type exclusively.

As a result of the Army's long and active endeavor in the solid propellants field, many of its missiles are based on this form of propulsion.

Some of the newer systems acknowledge the increasing interest in solid propellants, like the *Nike Hercules*, which will in time replace *Nike Ajax* and will have a solid propellant sustainer as well as booster. Both *Lacrosse* and *Hawk* will have this type propulsion. Even the somewhat larger *Corporal* will eventually be replaced by the *Sergeant* which will be powered by a solid propellant motor.

In view of the fact that solid propellant missiles at the end of the war were unable to compete performance-wise with liquid systems such as the V-2, one might ask how they have succeeded in such a short time in closing the large gap. Many factors shortened the time schedule; the following undoubtedly contributed:

1) The solid propellant motor is inherently very simple. Once basic research had established fundamentally desirable propellant properties and motor design criteria as a firm foundation on which to build, progress was rapid. It might be said as a corollary that the motor's simplicity also permitted fundamental solutions to problems rather than temporary or patch-up solutions.

2) Interchange of information on problems and developments has been quite free in the entire solid propellant field and all agencies have profited enormously. Unfortunately, the

problem of "proprietary rights" has entered the field so that the interchange is now somewhat restrained, but it is hoped that this problem can be resolved soon. As early as 1946 the Solid Propellant Information Agency (SPIA), jointly sponsored by all services, was created to further this objective. Important annual symposia and a strong reliance on SPIA by all solid propellant personnel are tributes to its success.

3) Very close liaison by U.S. Army user agencies and the Ordnance Corps has repeatedly guided and reoriented the research and development agency with respect to Armed Forces problems and requirements.

4) The solid propellant industry appreciated its early performance deficiencies with respect to liquid propellant systems and therefore concentrated on first things first. It minimized any duplication of effort and avoided in most cases an examination of areas that might offer fringe benefits only.

In periodically evaluating solid and liquid propellant systems for new applications, the Army's special requirements must be kept in mind constantly. Basically it is concerned with tactical rather than strategic weapon systems. It therefore demands high flexibility and unusual mobility consistent with the PENTANA concept of tactics in which units disperse to avoid detection and destruction but converge to fight.

Tactical units must be small, independent battle groups capable of operating for extended periods at long distances from higher echelons. They must no longer be roadbound and tied to a ponderous logistic tail but must have improved cross-country mobility through the increased use of cargo carriers and air vehicles. Much of the supplies to and within the field army must be delivered by aircraft of the assault cargo and convertiplane type.

Unlike the Navy which carries its home with it, or the Air Force which returns home each night, the Army and its equipment must be able to survive and function miles from civilization in an environment of extreme heat, cold, humidity, salt spray, fungus, sand or mud. In the chain of supply from factory to depot to launcher, experience had shown that even before PENTANA, the closer one came to the launcher, the more important it became to minimize manpower, equipment and problems of handling and maintenance. PENTANA now merely serves to emphasize this.

The fundamental objective of the missile system itself is to detonate a warhead on a given target at a designated time with a specified accuracy. Delays in launching can frequently be as serious as inadequate accuracy or range. The threat of counter-fire, too, prompts one to "shoot and scoot" when possible.

Missile ruggedness and reliability will also be of prime importance. Units must be capable of withstanding "humping" loads from railroads, vibration from aircraft, the jolting from trucks on rough terrain, as well as frequent loadings and unloadings, yet maintain a high degree of reliability.

The simpler the system, and the less it demands manpower having special skills or non-standard equipment requiring special maintenance, the more desirable it will be.

Solid propellant proponents are quick to point out that their inherently simple propulsion system meets most of these requirements quite well. With a pre-packaged motor, operations in support of the propulsion system are negligible. The need for a large number of nonstandard trucks, equipment and personnel with special skills, normally required for fueling in the field, is obviated. In addition, missiles stored with pre-packaged propellants are available on a moment's notice, a factor particularly important for anti-aircraft missions.

They point out, too, that the reliability of their propulsion systems is particularly noteworthy. Motors now in production, that have firing failures, ignition malfunctions, improper thrust program and motor failures constitute a very small fraction of the total number of high performance booster or guided missile propulsion systems used. The failure rate is less than one-quarter that of comparable liquid systems. Alternately, the amount of development time and money needed to achieve a given degree of reliability would be less for the simpler solid system.

Motor ruggedness in the field and transportability are enhanced materially by the stiffening action of the relatively rigid solid propellant charge, particularly when case-bonded. With the trend toward higher-performance missiles and lighter motor structure, this factor assumes more importance.

Of interest to programs developing large motors is the fact that solid propellant designs may be evaluated in small inexpensive motors and then scaled directly to large motors, which will have identical performance (except, of course, for those characteristics that should change with scale). Motors differing in weight by a factor of more than one hundred have confirmed this early proposition. Of interest, too, is the fact that no one has yet built a solid propellant motor too large to work successfully.

In large ballistic missiles the substitution of solid propellants for liquids in the tanks would eliminate the guidance complexity normally associated with fuel sloshing in flight. So, too, problems normally associated with control of liquid propellant mixture ratio are non-existent; in solid propellants the ratio is "frozen" at the factory. Finally, excessive axial accelerations that could penalize guidance accuracy can, in most cases, be avoided automatically by selecting an appropriate charge design; no separate mechanical devices would be necessary.

The report that the cost of solid propellants after loading in a motor exceeds that for liquid propellants is, in most cases, true. However, the cost of the complete propulsion system when metal parts are taken into account appears to be lower for solids because of their extreme simplicity. In the ultimate comparison, however, the relative propulsion costs will probably be determined by the extent that each influences the complexity and cost of their guidance systems.

It is important to maintain a proper perspective and recognize that solid propellant systems also have their problems and disadvantages. Most of these are concerned primarily with surface-to-surface ballistic missiles and the effects of propulsion characteristics on guidance.

The thrust level of most solid propellant motors changes much more with a change in temperature than liquid systems. This large temperature sensitivity increases complexity in guidance parameter setting (to admit temperature data) and increases variability or complexity of the flight computer markedly. These complications in guidance can be eliminated by temperature-conditioning the motor prior to its use.

A satisfactory method of varying the missile range precisely has yet to be established for solid propellant motors. Methods of cancelling or terminating thrust, comparable to propellant valve closure on a liquid system, appear to be very promising.

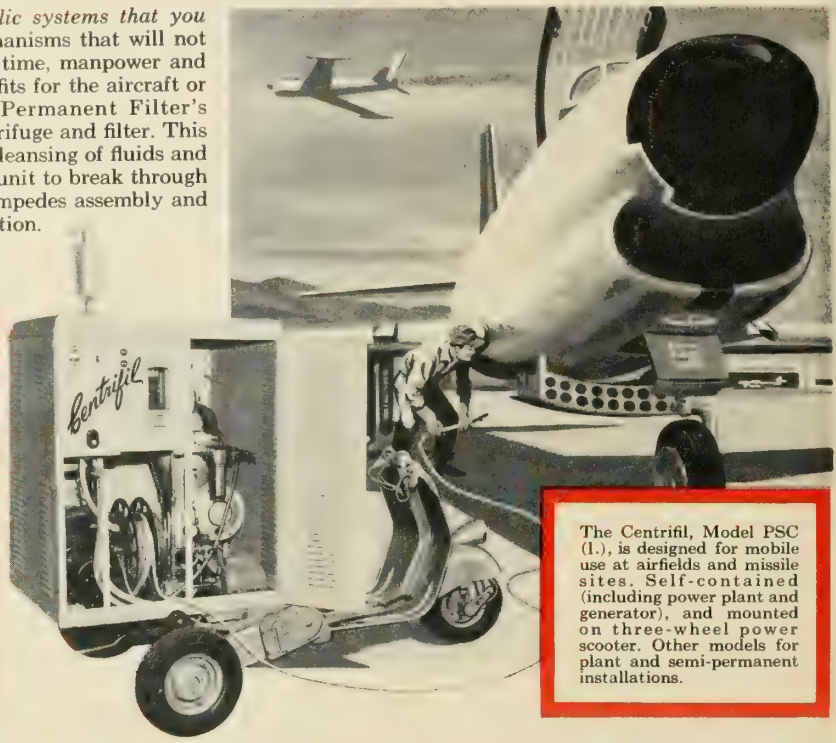
In some instances solid propellant motors exhibit irregular pressure fluctuations and motor vibrations typical of combustion instability. Guidance components then become damaged or degraded in accuracy. Fortunately, several promising cures have been devised to eliminate instability if encountered.

Finally, in the event that liquid rocket investigators succeeded in overcoming the problems in pre-packaged liquid systems without a serious penalty in weight and size, much of the logistic advantage that solid propellants now possess would be nullified. A second look would then be warranted. ★

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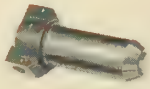
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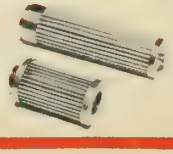
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Solid Propellant Rocket Testing

Accuracy is a must . . . so is quality . . . because the goal is perfection . . .

By H. E. Westgate

Grand Central Rocket Co.

ALL OF GRAND CENTRAL'S activities on solid propellants are vital and interesting but the testing phase is by far the most dramatic.

The scurry of activity by the various rocket technicians at a test site, their final withdrawal to the shelter of the operations bunker, the expectant silence of the final pre-firing phase culminated by the countdown: "5-4-3-2-1 fire"—these are the prelude to the roar and shaft of flame as the rocket responds to the signal from the firing bunker.

Technical organization for the test involves the Chief Test Engineer, his staff and three subdivisions or groups: the test mechanics group, the electronics instrumentation group and the data reduction group.

The rocket engines to be tested are of three basic kinds: the small research units supplied by the research department in order to determine the feasibility of certain rocket propellants or fuels; the larger experimental rockets designed by the Engineering Division for full-scale testing, and finally the well-established production units fired as part of the continuing check on the quality of production rockets.

Temperature Conditioning

If the rocket is of a type that will eventually be fired in the low temperatures of high altitudes or arctic conditions, the test firing may require a pre-firing conditioning or "soaking" at the extremely low temperatures to be encountered. Or, if the rocket is to be fired later under conditions of extreme aerodynamic heating or after being stored under conditions of tropical heat, a pre-firing conditioning at elevated temperatures may be in order.

In either case the mechanics will follow the test request and place the rocket in the proper hot or cold box or pit for the required number of hours prior to firing. At present Grand Central has 19 such conditioning chambers ranging in size from 2 to 20 feet in length.

Instrument Calibration

Coincidental with the final phases of the temperature conditioning of the engine, the preparation of the proper instrumentation for determining the rocket chamber pressure and gross thrust are readied.

Electrical calibrations alone suffice for some of the routine tests and are made with special electrical checking units. However, for many of the more precise tests the pressure pickups, which are installed directly on taps in the engine head and nozzle, are also hydraulically calibrated. This calibration involves the filling of each pickup with oil and pumping it up to exact pressure levels in a series of incremental steps.

When a rocket is expected to have a peak chamber pressure of three thousand pounds per square inch, the pressure pickup or transducer may be pumped up to one, two, three, four and five thousand pounds per square inch. Its electrical output is recorded at each one of these levels.

Later when the engine is fired these calibration points serve to fix with extreme exactitude the various points on the resulting pressure-time and thrust-time data. For even more critical testing, the same procedure is also repeated immediately following the test firing.

This later calibration serves to confirm the earlier calibration and to show with certainty whether or not any small change has occurred in the calibration of the entire system during the firing phase. Such double-checking is expensive and time consuming, however, and is reserved for the more critical tests.

Mechanical Preparations

While the electronic group is busy with the pre-firing calibrations, the



mechanical group is busy, preparing all the mechanical items necessary for a successful test. Among these are the nozzle, the head cap and the handling and mounting fixtures. The nozzles and head caps are generally not attached to the rocket until after engine conditioning since it is safer, especially at elevated temperatures, to perform the conditioning with the nozzles and head caps removed. In this state any accidental ignition would produce only a static fire since the engine could not develop appreciable thrust with both ends open.

When the allotted time for conditioning has elapsed the engine is removed from the conditioning box and readied for firing. At this point exact timing of the work counts and advance preparation and smooth teamwork pay off. The nozzle and head cap are first attached to the engine case and then the final attachment hardware are clamped on. The rocket is then transported quickly to the proper firing bay.

Installation of Engine in Firing Bay

To expedite this series of steps, the conditioning areas, assembly area and the firing bays are located as close together as permitted by safety considerations. Six large firing bays are currently available at Grand Central's Redlands test site. All bays are of the type which secure the rocket engines in a horizontal position. This type has been found to be most convenient and minimizes the requirement for overhead handling equipment. All of the bays are equipped with heavy structural rails imbedded in thick reinforced concrete floors. These rails provide a strong anchor for the engine test stands.

The test stands are cradle-like structures which serve primarily to support and anchor down the rockets during the test firings. Some are merely used to support and hold down the motors. Others allow the motor to shift slightly forward when firing and so exert the firing thrust on measuring instruments. These in turn relay this information electronically to the instrument bunker.

Engines to be operated under specific high or low temperatures have to be capable of properly igniting under those conditions. As soon as a rocket is removed from a conditioning box its temperature naturally starts to return to the temperature of the existing surroundings. It is therefore necessary that the engine be fired as quickly as possible after its removal from the conditioning box if the required high or low temperature firing is to be a valid test.

The mechanical operations of properly installing a rocket in a complex firing stand may, by virtue of the existence of special mechanical features, require upwards of a hundred or more bolts in this final assembly. Likewise, a complete complement of electrical instrumentation to adequately determine chamber pressures, case temperatures and strains along with the thrust, may involve the last minute installation and electrical hook-up of as many as thirty or more electrical pickups and gages. These last-minute electrical and mechanical operations must therefore be performed under stringent time limitations which necessitate precise and efficient operation.

In some cases the speed element can be successfully slowed down by constructing a hot or cold conditioning box right in the firing bay surrounding the engine itself. This saves last-minute time but in general adds so much complexity to the test that this method is not as widely employed as might be expected.

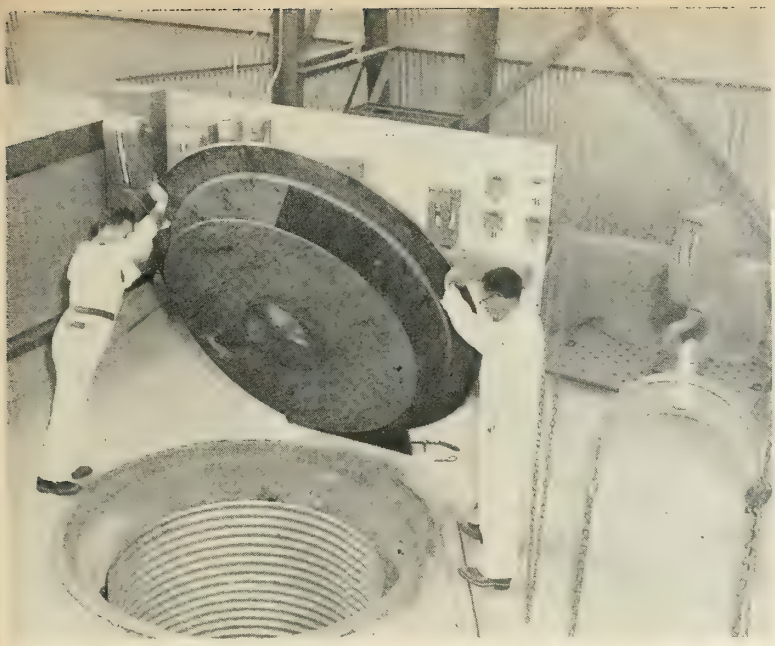
Firing Instrumentation

Solid propellant engines may, depending on their size and grain configuration, burn anywhere from a fraction of a second to several minutes. In either case precise recording of the electric signals coming into the instrument room from the various instruments on the rocket is essential. These signals, when interpreted later, give the detailed technical picture of the firing. Hence there is a need for the fastest and most accurate recording devices.

Firing test data at Grand Central is generally recorded on long rolls of light-sensitive paper, the data being traced on the paper during the firing by banks of accurate, light-beam galvanometers. An eight to ten foot strip of paper 5 to 12 inches wide, all filled with a seemingly meaningless series of curved, wiggled, interrupted and otherwise deflected galvanometer traces may constitute the entire data from a firing which may last less than a second but, which may cost hundreds or thousands of dollars in materials and man-



Latest addition to Grand Central's facilities—three test bays for static firing small and medium-sized solid-propellant rocket motors.



Attendants remove the lid from a large vertical pit-oven preparatory to curing operation.

hours of testing time.

For tests of longer duration, the results of a single test may cover several hundred feet of this same paper. From the complexity of the lines and the length of the paper the subsequent job of data reduction can be readily appreciated. In most cases the roll or rolls, known as "the record" generally represent about 80 per cent of the data from a typical test firing.

Additional data is obtained visually by direct viewing, regular movies, high-speed movies or closed-circuit television. Additional audio information may be obtained directly by listening or by a more accurate microphone-tape recorder combination.

Grand Central has just finished installing at the Redlands test area a completely new automatic fire control console and associated racks of the necessary power supplies, amplifiers, monitors, and recorders. A wide variety of both D.C. and carrier amplifier recording channels are provided. By utilizing a system of switchboard plugs any combination of amplifiers and recorders may be plugged into lines extending to any of the six firing bays.

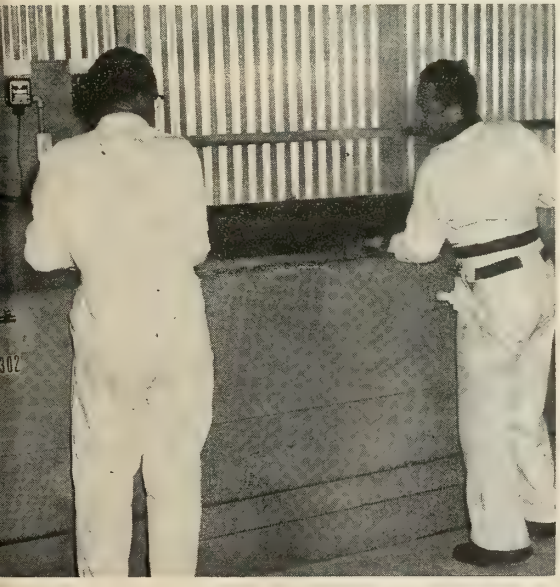
Firing

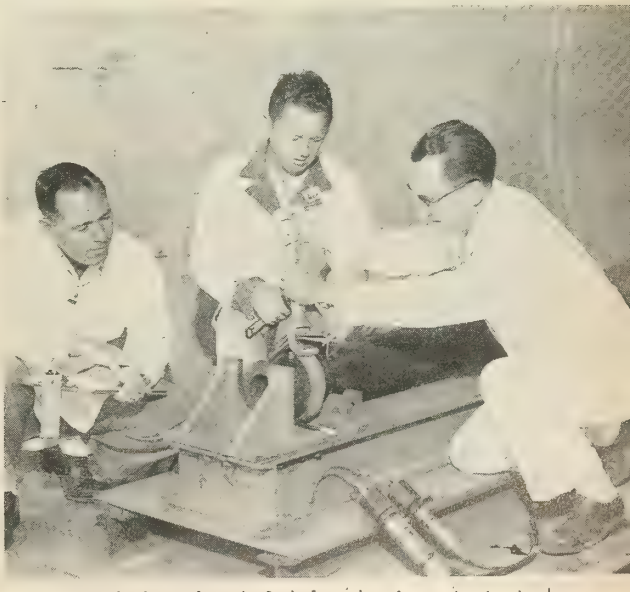
When the engine has been finally installed in the firing bay and all the instruments have been calibrated and attached to the motor, the engineers make their final checks and the time comes for the last minute operations. The test safety man checks the firing area and withdraws, progressively arming various key points of the firing lines as he leaves.

The safety man also brings the connecting safety "jumper" which is the final electrical link to complete the current flow between the firing console and the igniter. This jumper, which he carries at all times when working with a rocket in the bays, is his assurance that no one can fire the rocket before he and his men are safely in the observation bunker.

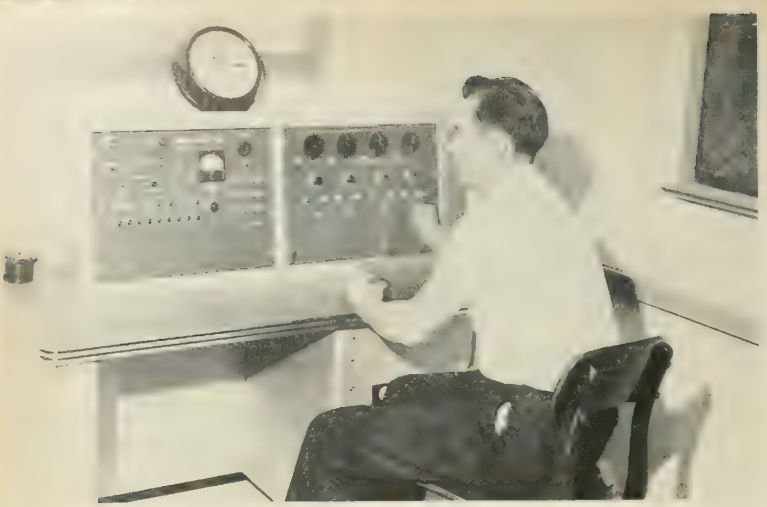
This jumper is now inserted in its proper socket in the firing console. When the instrumentation technicians are sure that all their recording gear is ready, they switch on the firing system, thus arming the firing console.

The firing operator then pushes the firing button. From here on the operation is entirely automatic and thus eliminates the possibility of any last minute errors of the test personnel. The firing console starts the electronic five minute countdown. Safety gate locks are monitored, and if any are left open or are later opened, the console will "kill" the firing. When the





LEFT—Test mechanics lowering a motor into a conditioning box. RIGHT—Final checking of nozzle fit before clamping motor to stand.



A portion of the instrumentation room which houses the power supplies, monitors, amplifiers., recorders, and switchboard panels for instantaneous channeling and recording data.

unit reaches the X-minus-thirty-second point the count-down delays begin to turn on cameras, recorders and other testing devices.

The electronic voice recorder drones out the verbal portion of the countdown in perfect synchronism with the timing unit. When it calls "Fire!" the rocket engine igniter is fired and the rocket engine surges to life. After the firing is over there is a brief wait which is terminated by the familiar all clear signal.

Post-Firing Procedure

Following the all-clear signal the test mechanics start to dismantle the mechanical set-up and the electronics group unloads all the recorders and cameras and process the film and paper. The engine itself then comes in for some further study.

Auto accident analysts and air crash investigators have nothing on rocket development engineers when it comes to the analysis of charred engine parts, or in cases where there is an engine malfunction during testing.

The spent shell of a burned-out or fractured rocket engine may seem a worthless item. Actually the reverse is true. A normally spent rocket test engine is always carefully handled and precisely weighed to determine the degree of completeness with which the propellant grains burned. The nozzle is inspected for flame erosion, residues and high temperature effects. The final nozzle orifice size is recorded by micrometer readings or micro-projector diagrams.

In the case of a malfunction, the analysis is even more thorough. This is generally true for two reasons. If the engine's performance was unique, unusual or just plain undesirable it is vital that the results be sifted to determine the exact causes of the particular malfunction.

Depending on the violence of the malfunction, it is possible that important instruments may have separated from the engine at the moment when the most enlightening data was being obtained. In the case of total failure the fragments of the rocket chamber and nozzle are methodically collected and fitted together to try to determine whether the failure was due to heat, pressure, imperfect parts or other causes. Often a sharp or dull-edged fragment, a tiny scorched piece of the case or a battered nozzle will give the clue as to what corrective engineering has to be undertaken.

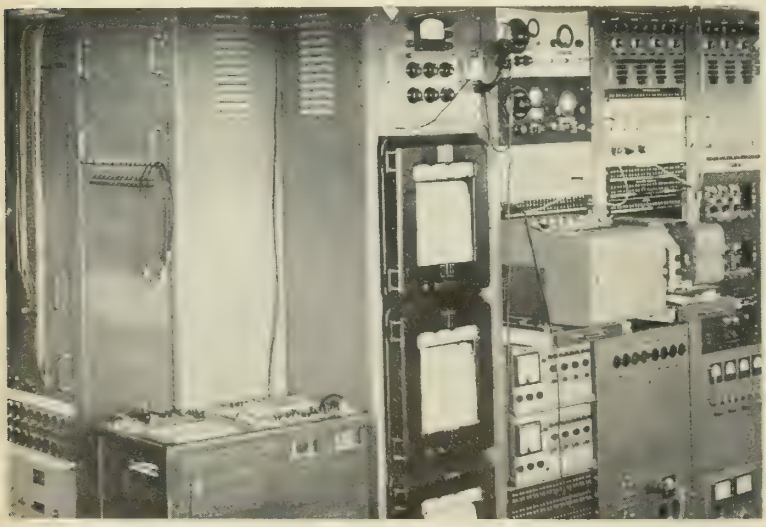
When all the data from the recorders, cameras, observers and inspectors has been collected and the initial photo-processing, logging, marking and other basic operations have been completed, the combined and somewhat heterogeneous collection of information is ready to leave the test site and forwarded to the data reduction group.

Data Reduction

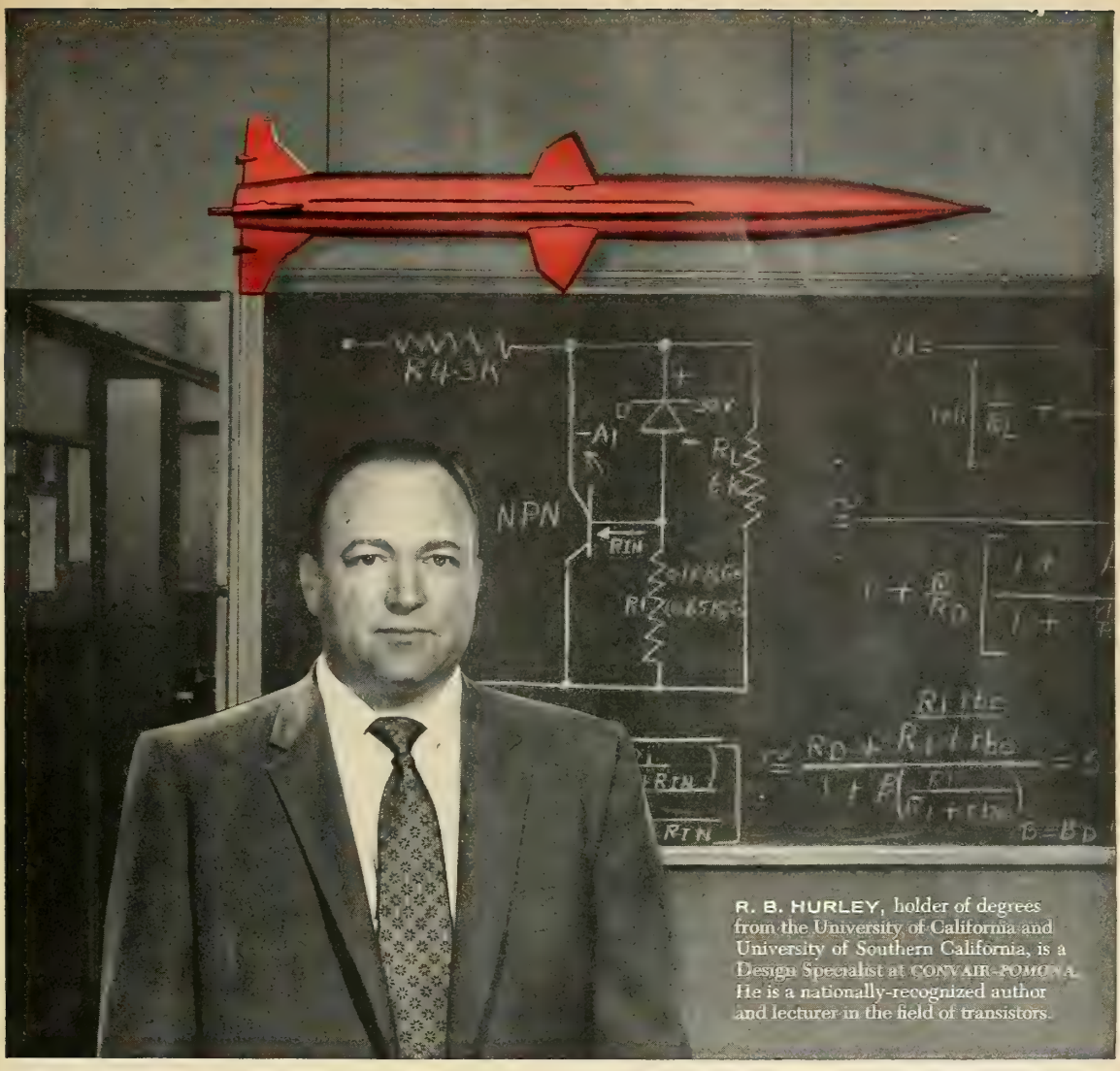
The tools employed by data reduction computers are primarily translucent "light-tables" (for properly inspecting the test records), scales, planimeters, sliderules and conventional calculating machines. The test data is thoroughly analyzed with these tools by converting the traces on the record rolls to typed data and charts which give engine burning time and thrust, combustion chamber pressure and wall stresses, nozzle temperatures, propellant specific impulse and other useful engineering information.

The New Remote Test Site

To meet the continual need for testing very large solid propellant rocket engines, Grand Central has set up a large motor test facility in an 1800 acre portion of an 8000 acre isolated mountainous area near Beaumont, Calif. Instrumentation vans have been obtained and are being equipped to provide mobile instrumentation facilities for this new Beaumont area. One large firing bay is already in use in the new test area and other bays are under construction in line with the need for continued and expanded work in the field of solid propellant missile development. ★



Grand Central's new fully automatic firing console. The panel includes the rocket motor operating controls, count-down lights, and camera and recorder time-setting controls.



R. B. HURLEY, holder of degrees from the University of California and University of Southern California, is a Design Specialist at CONVAIR-*POMONA*. He is a nationally-recognized author and lecturer in the field of transistors.

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Swing to Solid Propellants

gaining momentum in missile planning

By John Wilson

Atlantic Research Corp.

CONTROVERSY BETWEEN liquid and solid propellant engineers over the relative merits of their propulsion system seldom leads to an impartial analysis of exactly where the two types stand in the current state of the art. A comparison of the present status and possible future status of the two systems is needed. It is needed not only by military planners, but by rocket and missile engineers who need to know the probabilities and the possibilities of development. The missile propulsion systems now in the dream-and-scheme stage can then take shape around the anticipated propellant developments.

Transportation planners are also interested in future propulsion possibilities for missiles. The big question mark here—how soon may we start using missiles for passengers, mail and freight deliveries? Nonmilitary uses of rocket power in the past have been limited largely to aircraft-assisted-take-off units—JATO bottles.

Planners now count on rocket power for routine transportation possibly within the next quarter of a century. In order that this go beyond the Buck Rogers day dreaming stage, costs must be drastically reduced to compete with air rates. Big technical problem to be solved is bringing the missile down safely, and exactly where you want it.

Current Status

Evaluation of the liquid versus solid propellant systems currently in operation must consider other types of propulsion now being used.

Turbojet applications, although limited because of altitude and subsonic speeds, power the *Petrol, Matador, Regulus,* and *Snark* missiles. Ramjets, operating from subsonic to Mach 5 or better at altitudes up to 100,000 feet, propel the *Bomarc, Talos, Navaho,* and *Triton.* The turbojet *Snark* and ramjet *Navaho* both have 5,000-mile range, but certainly neither should be compared to the liquid-propelled ICBM *Titan* and *Atlas.*

Ramjet and turbojet powerplants will continue to be used for manned and low-speed, low-altitude missiles, filling both military and civilian needs. It is in the long-range, high-speed missile field that liquid-propellant or solid-propellant systems will be called to supply the needed power for the immediate future.

The liquid propelled missiles are the most glamorous and consume the major part of missile funds. In contrast, there are a greater number of solid propellant missiles. Most are of small size for tactical missions.

This decided movement toward using solid propellants for a greater number of missile systems stems primarily from the difficulties involved in handling liquid propellants.

Advantages and disadvantages of liquid propellants are familiar to all missile men, and are quickly recited. Specific impulse is now up to 25% greater than for solid propellants. The operation pressure can be low, heat transfer can be regulated, and the rate and richness of the fuel oxidizer ratio can be regulated. However, it is in this separate handling of fuel and oxidizer that liquid propellants cause the most grief.

In the liquid propelled rocket plumbing becomes an outstanding and overwhelming engineering problem.

Solid propellants, with a lower specific impulse and presently lacking the control features which liquid propellants possess, has, in its ease of handling, a big lever with which to topple liquid propellants from their historically predominent position.

Missile work gets its big impetus from the military planners, and what the military decides is by and large the direction missile development is going to take. Defense appropriations pay for present missile research and development and any peaceful applications must involve as few modifications as possible. Aside from defense allocations there isn't enough available money for fruitful peaceful missile development.

Liquid Propellant Missiles

First consideration will be given to the liquid propellant missiles, which, in addition to their glamour value, have involved multi-billion dollar expenditures. The known missiles in this category are: *Rascal, Corporal, Nike Ajax, Titan, Bomarc, Jupiter, Redstone, Thor* and *Atlas.*

The Air Force intercontinental ballistic missiles, *Atlas* and *Titan* and the intermediate range ballistic missile, *Thor,* are liquid propelled. The Army has *Redstone* and *Jupiter,* although prospects of the *Jupiter* is clouded since Secretary of Defense Wilson gave the longer-range ballistic missiles to the Air Force. It is felt that the story is not yet completely told; and although the *Jupiter* missile is within the range stipulated, work continues. The mass-produced *Nike-Ajax* is the missile that the Army has deployed for defense all over the world. It is, by far, the most operational missile today.

Liquid propellant missiles owe much to the success achieved by the German scientists of Peenemunde during World War II. Many refinements have been made since and a lot of perplexing problems have been answered. Essentially the advances made in American liquid propulsion systems are not far removed from the German technology. Many engineers feel these same German missile men have been allowed to dominate the liquid propellant thinking.

As is repeatedly pointed out, it was solid propellants that got a head start, beginning with the Chinese rockets of the 13th century. Liquid propellants have had the longest record of concentrated development activity. Goddard's first experiments with liquid propellants began in 1921; his first liquid-propellant vehicle was launched in 1926.

Before World War II, major rocket development effort was concentrated in Germany, predominately in the liquid propellant field. Thus, liquid propellants have a continuous 35-year development history. Solid propellants had their first serious start during the last war but major effort has come only since the war. At most, solid propellants have a 15-year history of concentrated development.

In the meantime liquid propellant men are striving for plumbing simplicity. A benefit of this simplification would be the successful design of a small diameter liquid propellant missile. The best prospect today is the Naval Ordnance Test Station's 5-inch liquid-bipropellant aircraft rocket (LAR). Although this missile is unguided, the propulsion system, if successful in operation, could be applied to smaller tactical guided missiles.

Development of a monopropellant that could be handled as safely as aircraft fuel would give ease of handling both in servicing the weapon and in design of the missile system. Development of a liquid monopropellant presents many of the problems of a solid propellant, which is also a "monopropellant".

Swing Toward Solids

The listing of solid propellant missiles is more extensive and diversified. It includes the most outstanding operational or near operational: *Gimlet, Mighty Mouse, Zuni, Falcon, Sidewinder, Sparrow, Bull Pup, Hawk, Tartar, Terrier, Dart, Honest John, Little John, Sergeant, Lacrosse,* and *Polaris.*

The greater number of missiles, when compared with the liquid propellant list is immediately evident; not that either list claims to be exhaustive. Evident also, of course, is the size range, from the 2-inch *Gimlet* and 2.75-inch *Mighty Mouse* to the 30-inch *Honest John.*

Key entry among the solid propellants is the navy's intermediate range missile *Polaris.* Until it was decided to develop *Polaris* as a solid propellant missile, the down-to-earth thinking on large missiles was in liquid propellants. The barrier to large solid propellant missiles has apparently been breached.

In view of other shipboard missiles, either solid propellant or jet propelled, such as *Terrier, Regulus, Sidewinder,* the Navy's decision on *Polaris* was to be expected. Considering the difficulties present in carrying aircraft fuels aboard ship, there is little chance the Navy will involve itself with difficult-to-handle liquid propellants.

H. S. Seifert in an article on the development of missile propulsion for the last 25 years in "Jet Propulsion," November 1955, forecast the *Polaris* decision.

"Liquid rockets have held the lead as motive power for large-scale, long-range applications, but even here new developments in solid rockets indicate that this supremacy may be challenged."

It would be premature to say that the supremacy of liquid propellant propulsion systems is challenged. It is evident that for large-scale, long-range, high-speed applications, movement is under way to break the monopoly of liquid propellants. Messrs. Stehling and Foster (m/r, Oct. 56, p. 58) proposed a rocket vehicle for a flight to the moon utilizing a solid propellant propulsion system. Considering the practically religious adherence to liquid propellants for this chore in the past, this would almost constitute a major breakthrough.

An outstanding example of solid propellants leading over liquid propellants is research rockets. Ease of development and handling are mandatory for research rockets. The only liquid propellant research rocket is the *Aerobee,* and *Aerobee-Hi.* The solid propellant research rockets now in use are: *Arcon, Asp, Deacon, Cajun, Dan, Iris, Rockaire, Rockoon, Terrapin,* and *Wasp.*

Synthesizing of the composite solid propellants has spearheaded the drive into the longer-range high-speed field. A new development in solid propellants was needed if they were to keep pace with modern needs.

The prevailing philosophy of World War II and immediately thereafter was to use large quantities of relatively short-range missiles to insure a reasonable kill probability. This is the barrage or saturation approach. Today, however, reliance is more and more being placed on a very few units of long range and high accuracy. We might call this the pin-point approach.

Solid propellant internal-burning grains were ideally suited for saturation tactics but they find considerable difficulty in meeting the new demands made upon them. There is an urgent demand for an end-burning grain which will answer the strategic and tactical need, including those of ballistic missiles. This need is being met by composite propellants.

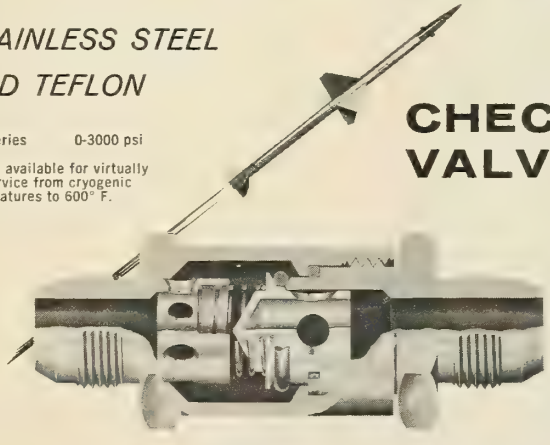
In contrast, liquid propellant technology has shown no similar break-

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through. To make this breakthrough composite propellants must be considered. It is the development of composite propellants which has made possible such propellant systems as the *Polaris*. It is possibly a polymer-based composite propellant, since Aerojet has done extensive work in this field.

These composite solid propellants are drawing great interest as the propellants that will speed tomorrow's rockets—such as rubberbase-polymers at Thiokol, as well as Aerojet's polyurethane-base.

Despite this advance afforded by composite propellants, solid propellant systems suffer a serious impediment. Traditionally, a solid propellant system is a constant energy device which cannot be metered for operation. This obstacle can and is being overcome, although the details are still classified.

If development of solid propellant military and research missiles is moving into the large-diameter long-range field that liquid propellant has had staked out for itself, then it is indicated that solid propellants are going to be next to impossible to stop.

Ion-Atomic Propulsion

The challenge, of course, to both liquid propellant and solid propellant systems is ionic or nuclear propulsion. Latest in the ionic propulsion category is the plasma jet with high temperature and low thrust. Solve the metallurgical problem of high temperature and boost the missile out to where the low ionic thrust is all you need and you're in business. It has been proposed that a rocket boosted to the ionosphere could pick up enough energy with solar batteries to continue on its way.

Barring an unexpected breakthrough, missiles of the immediate future will be propelled by liquid or solid propellants.

The propellant systems may, however, be hybrid. A system utilizing liquid oxidizer for a solid fuel has been designed. Systems such as *Vanguard* with the first two stages liquid and the last solid might be considered hybrid. But so then must all the liquid propellant missiles with solid propellant boosters and gas generators.

It is certainly possible that such hybrids will win out over "pure systems" of strictly one propellant. What will happen and has happened is that each system will be used, alone or in combination, as conditions dictate.

It is current operational conditions which are dictating the pronounced swing toward easily handled, increased performance, composite propellants. Startling new developments in solid propellants should be expected in the near future.★

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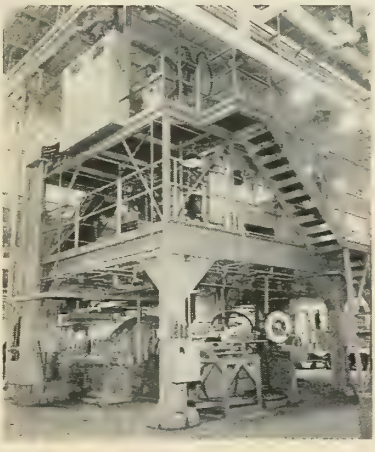
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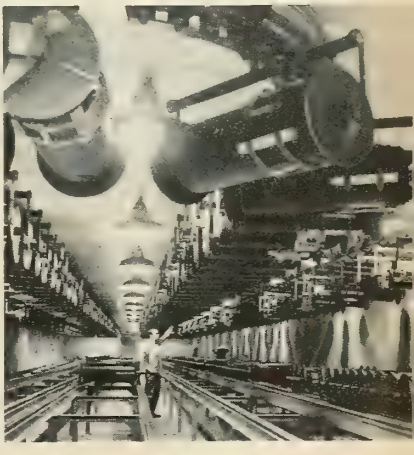
Phillips Petroleum Co., a major factor in solid propellant development and production since 1952, is contractor-operator of Air Force Plant 66 at McGregor, Texas. Phillips' Rocket Fuels Division's first major development was the M15 JATO. Phillips also lists three large off-the-shelf booster units for military missile and sled applications. Units are: Pusher, Producer and Megaboom. RIGHT —Temperature-conditioned booster unit is systematically checked before test firing.

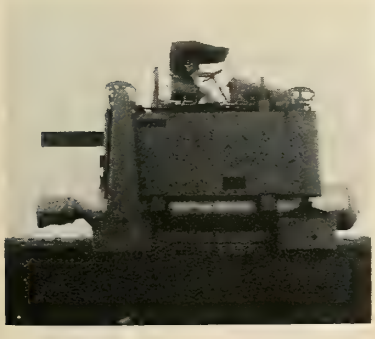


Air Force Pushing Big Pushers

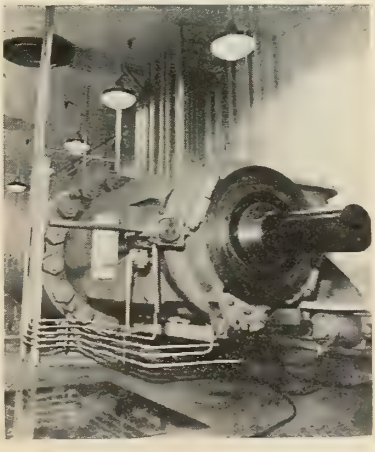
RIGHT—Solid propellant mixing machinery. FAR RIGHT—Propellant grains moving along conveyor belts in cooling room. BELOW—Lift truck used by Plant 66 for transporting complete solid propellant motors in the plant.

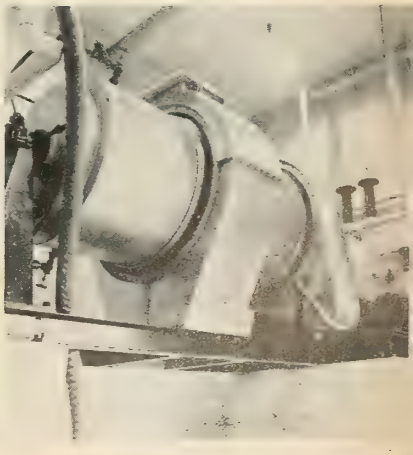




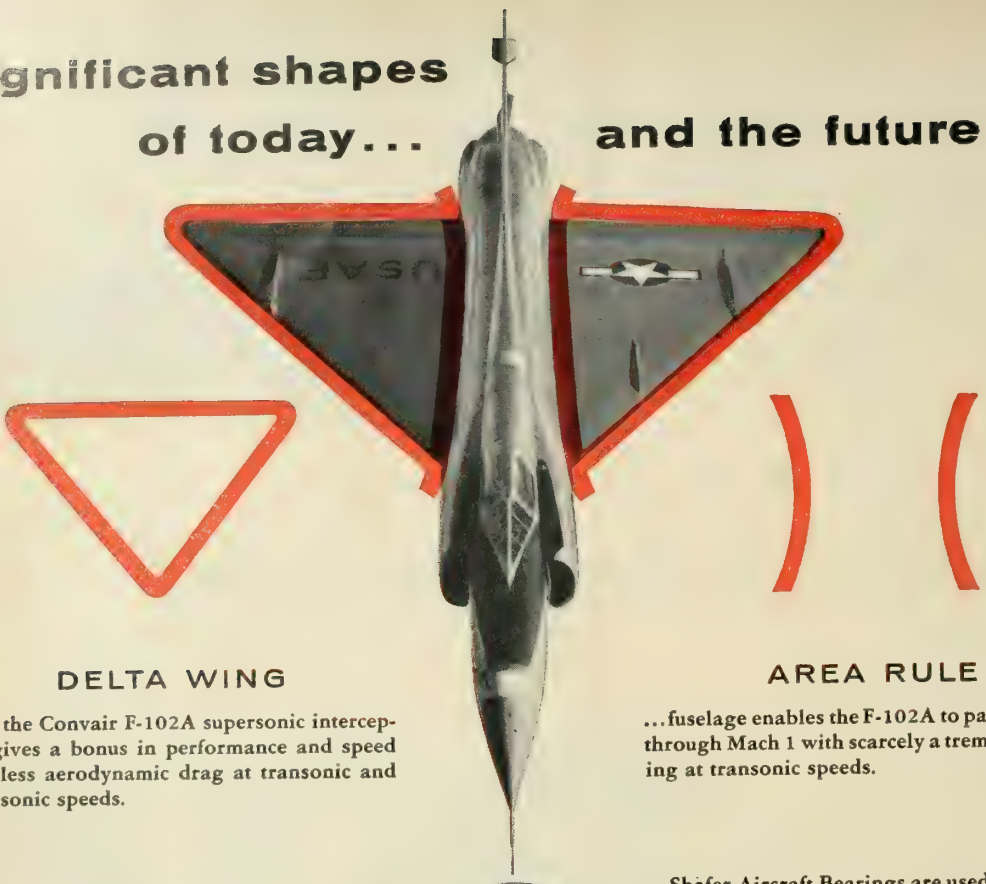


RIGHT—A batch of propellant emerges from an extruder. An attendant, through remote control closed-circuit TV, operates the processing machinery. FAR RIGHT—Rotary vacuum reduces moisture content of a solid ingredient used in rocket fuel development.





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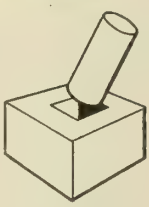




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New High-Heat, Low Cost Fuel Reported

MISSILES AND ROCKETS has learned that preliminary work has been completed on a new concept in high energy fuels. The new fuel is said to combine ultra heat of combustion, good handling properties, and after a low molecular weight, all gaseous, smokeless exhaust. The compound and its combustion products are non-toxic. Further, the fuel is apparently stable when pure. Though not named, the fuel can be burned in air, or with any conventional oxidant. Reports state that higher heats of combustion (BTU/gal) over conventional hydrocarbons or metal hydrides are in evidence.

Perchloryl Floride Now on Market

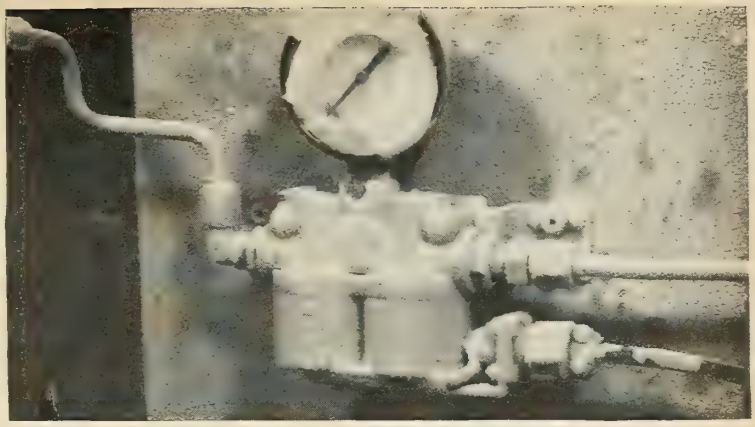
Perchloryl fluoride, C103F, is being introduced by Pennsalt Chemicals. Available in pilot plant quantities, PF is a gas (bp-52 F) which can be safely stored in liquid form (critical temperature 203°F, critical pressure 53 atm, specific gravity 1.4). High reactivity is a feature of the colorless, non-corrosive material with a characteristic sweet odor. PF is said to be thermally stable to 500°C and stable to mechanical shock but reacts on contact with most organic materials. Acute vapor toxicity is placed at 2000-4000 rpm (4 hrs. exposure).

Oxygen Generating Plant Nearing Completion

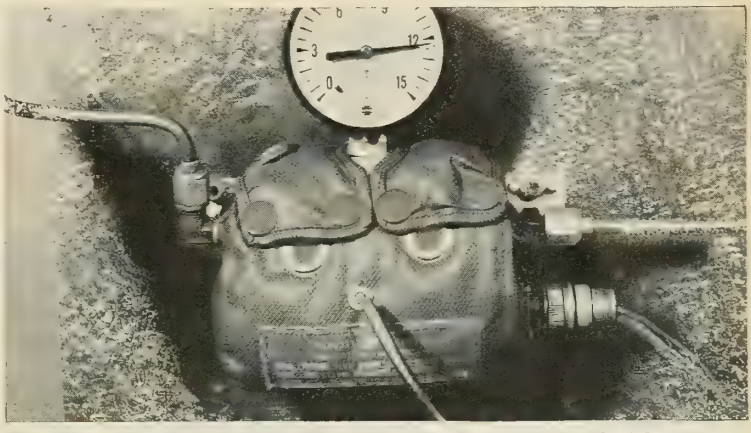
New $5.5 million liquid oxygen generating plant now nearing completion at the Experimental Rocket Engine Test Laboratory at the Air Force Flight Test Center, Edwards AFB, will produce 150 tons of liquid oxygen daily, with 15 tons of liquid nitrogen per day as a byproduct. Latter is used for prechilling liquid oxygen missile tanks and pressurization of component missile equipment.

Solid Motor Cases Made of New Plastics

Polcarbonates-condensation products of phosgene and bis-phenyl-A are now appearing as high-impact and tensile strength plastics which may soon wind up as motor laminates or possibly as a fuel-binder for solids. GE has come out with its "Lexan" polycarbonate while Bayer of Germany and Eastman Kodak are also doing work with this material.



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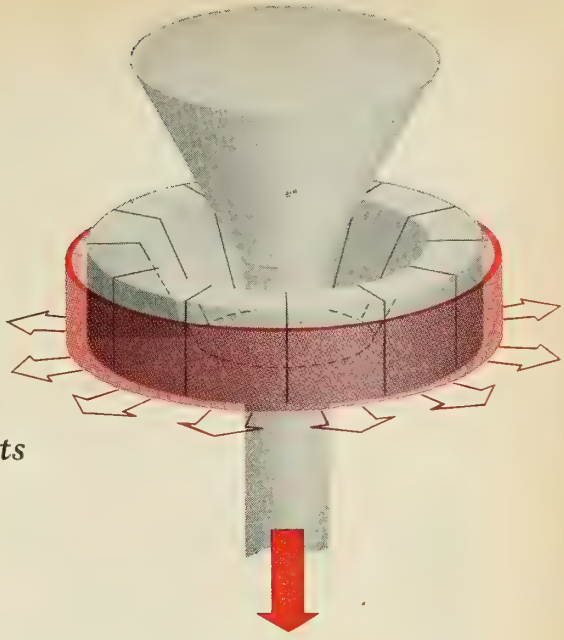
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Evolution of a Method

By George Shaw



Grotnes Machine Method Adapts to Production of Power-Plant and Missile Components

WHEN CHARLES C. GROTNES launched his business in 1898, building machines to produce tapered steel barrel hoops, his product was geared to that age. Today, more than 50 years later, they are doing essentially the same job of forming metals, but in a more complex manner and on a vastly larger scale; as much at home in the age of the atom as in the barrel shop.

Die casting, drop forging and stamping processes have been in general use almost as long as metals have been formed by machinery, but the method of altering the shape of cold metal by expansion and shrinking started with Grotnes. The basic principle involved is fairly simple and very adaptable. In fact, the magnitude of the jobs it can perform is only limited by the size of the equipment available, and this explains the enormous size and power of some of the Grotnes machines in use throughout the world.

The name plate on a piece of Grotnes equipment bears the legend, "equipment for expanding—shrinking—rolling of metals." The legend suggests a line of exceptional machines which will form a piece of cold plate to almost any shape required at low cost and at a high rate of production.

It does not, however, suggest the wide application of these machines to an age that creates new and complex problems in metalworking almost daily. The wooden barrels have given way to guided missile parts and freezer cabinets; to washers and dryers and irrigation pipes, and the machines have kept pace. The method remains the same but the machines have grown in magnitude and in utility until today there is a Grotnes machine that will shrink or expand a piece of metal into a cylinder, a square or a polygon.

Demand for Auto Rims

Shortly after the turn of the century the automotive age began its slow roll into the realm of heavy industry. The new carriages, if they were to be really efficient, had to have steel rims for their rubber tires. Grotnes was called upon to develop a method to form and mass-produce the rims.

The hoop expanding machines were turned to production of steel rims, and Grotnes became associated with the tremendous surge of mass production in the automobile industry. Today practically all of the automobiles, trucks and agricultural machinery in the world roll on rims produced by Grotnes machines, or on machines using the Grotnes method.

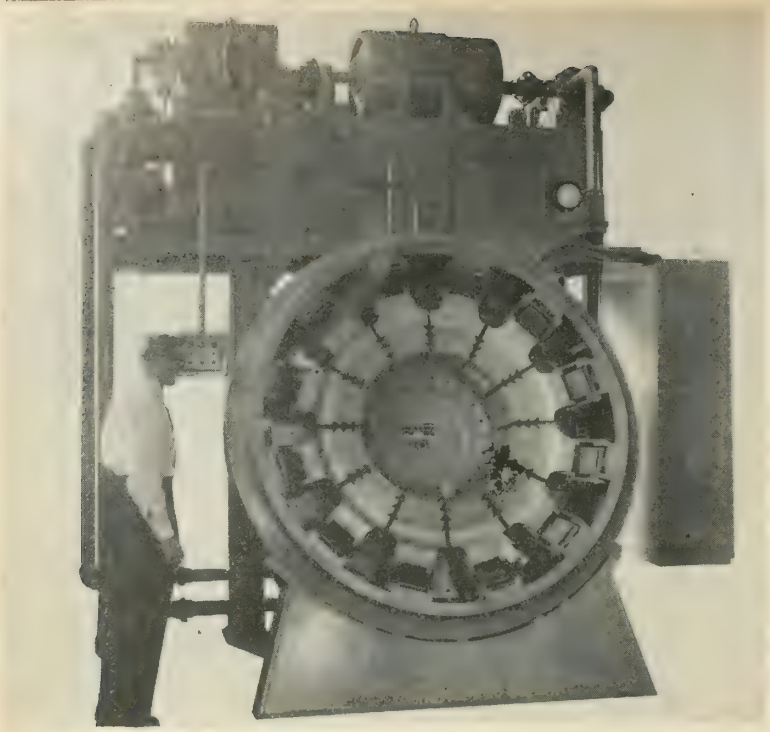
Of the three basic operations comprising the Grotnes method the rolling operation is the least adaptable. While the rolling operation can only be performed on a cylinder or "coil," the expanding and shrinking operations range from, and to, any shape desired.

The cylindrical stock is formed on a weld roller, an operation that rolls the weld into the metal comprising the sheet stock and the weld is smoothed out on a Grotnes weld roller. This coil, as it is called, can then be rolled, shrunk or expanded to any shape required, without heating. Some of the more complicated operations may call for annealing between steps, but generally the forming is done without the need for treatment of the metal as in other methods.

In the production of a jet engine ring, the coil first goes to an expander where a channel or bead is expanded into the center section of the cylinder. This first operation facilitates the last one, where the coil is slit to form two rings identical in size and configuration. When the bead is expanded the coil is placed between two rings, one an expander ring and the other a hold-back ring. Corresponding dies in the two rings allow for consistent control of very close tolerances.

The coil then goes to the rim rollers for profiling. Two hydraulically operated spindles, mounting suitable tooling for the profile desired, form the rim in a continuous operation. The upper spindle is fixed, while the lower one is moved upward against the rim by hydraulically operated toggle linkage. Thus a differential can be provided in the gear train of one spindle and thereby reduce slippage between the roll and the part.

Rates of feed can be varied so that in any given operation the desired number of turns will be provided to form the desired contour. Cold forming of metals this way is said to materially improve the mechanical properties of the metal and uniform thickness is maintained throughout the part.



View looking into the 'maw' of a shrinker. Simplicity of operation can be seen in the control box arrangement at left. This shrinker sizes heavy ring sections of stainless steel, aluminum, alloy steel and titanium.

More ecnomical production is claimed for Grotnes machines than with processes which, in principle, can produce the same results. The reasons cited are, simpler manufacturing processes, versatility and adaptability. Quick changeover of forming rolls permits handling of a wide range of shapes and sizes of materials. As noted earlier the rim roller can only handle circular material; however with the expander and shrinker the dies on the machines can be adjusted to handle any shape.

The Grotnes expander is probably one of the most fascinating pieces of machinery ever devised for general application. No quality or characteristic of metal is overlooked in the design of expander principle and operation and surely there is no more versatile a mechanical apparatus in the metalworking field. To borrow a simile from the machine—any improvement in the expander is an expansion of the principle itself.

Such metals as mild steel, alloy steel, stainless, titanium and aluminum can be formed on the expander and the process is called the most economical means of forming and/or sizing any part having a continuous cross section —round, square, oval or polygonal. Subassemblies can be joined by the

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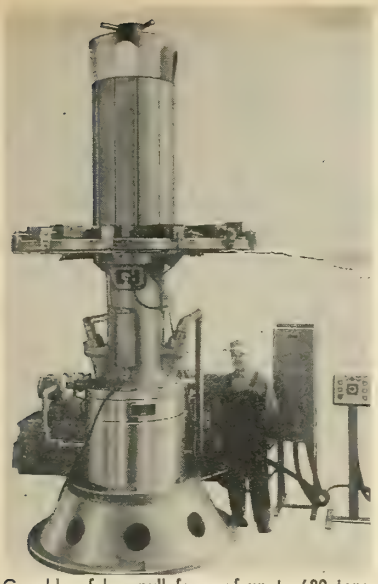
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Capable of bar pull force of up to 680 tons, the machine pictured above is one of the largest expanders in general use. This machine sizes and forms jet engine parts such as cones, rings and cylinders.

process without resultant distortion such as with welding or bolting.

In another application such heavy sections as jet engine rings, hydraulic cylinders and motor frames can be expanded to rough size, considerably reducing machining time and material waste. Expanding is also widely used in testing weld strength and in improving welds and the adjacent metals. Though expanders are designed for use in forming a specific part they are generally adaptable to a certain degree.

The expansion process is simpler and more accurate than any other method known. For instance, in the case of a ring that must be joined permanently with another ring, one within the other, the expander usually does the job in one operation. The outer or larger ring is enclosed by a hold-back ring. The expander presses the smaller ring into the larger one in a permanent bond and the hold-back ring retains the shape and outside diameter of the whole. The inside diameter is established by the expanding dies.

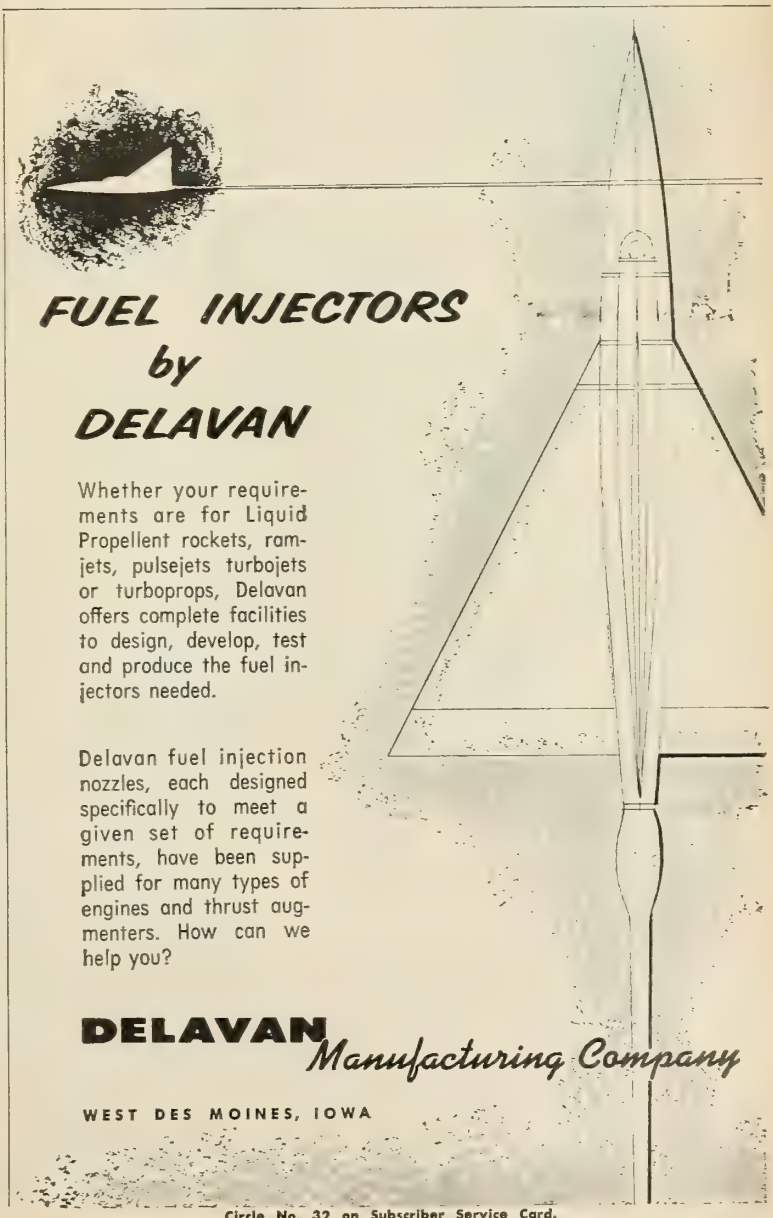
Although the bulk of expander production is concerned with circular or cylindrical parts, it can and does handle a variety of odd and unusual configurations. A wide choice of dies and die arrangements permits an almost unlimited choice of single and multiple operations to produce a desired shape. Once the machine has been set up and a couple of control tests are run, the machine can be run on a production basis, capable of extremely high production rates. A good example is a machine used in the container industry which will turn out 2000 curled, beaded, offset and flanged pails per hour.

As noted before, the basic principle of the expander is fairly simple. However, in the modern versions of the machines a number of inter-related variables tends to complicate the process considerably. The basic principle is that of the inclined plane or wedge, actually a polysided cone resembling a modified frustum of a pyramid. In addition to the cone the basic elements of the expander are the drawbar, jaws, table and power system. The cone is attached to the drawbar which may be hydraulically or mechanically operated.

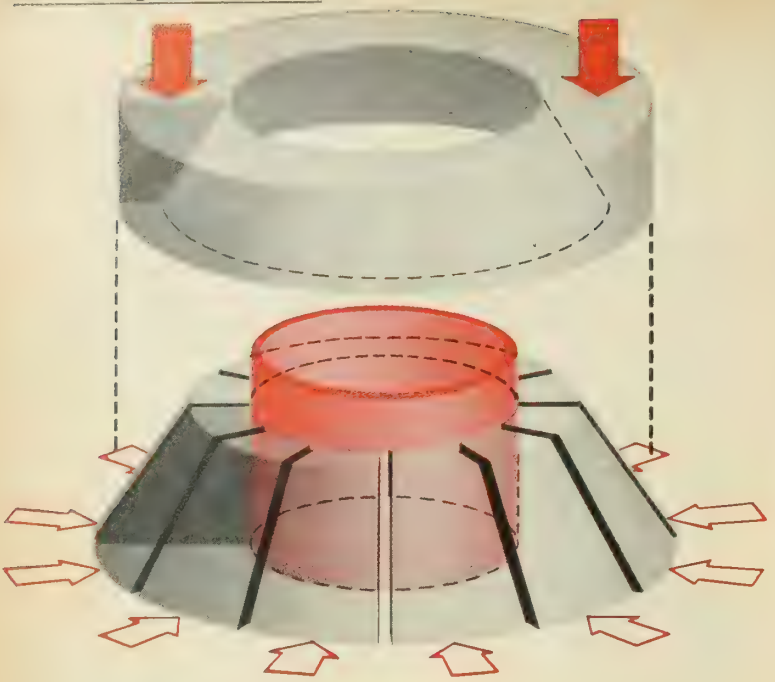
The movement of the cone being drawn down between the jaws forces the jaws outward at right angles to the cone travel. The jaws move through slots in the table provided for this purpose. The dies for a particular operation are placed on the jaws and as they are forced outward they move against the part to be molded or expanded. The part is placed over the jaws and as the cone is drawn down the metal is stretched until the cycle of the cone travel is completed.

Wide Range, High Production Rate

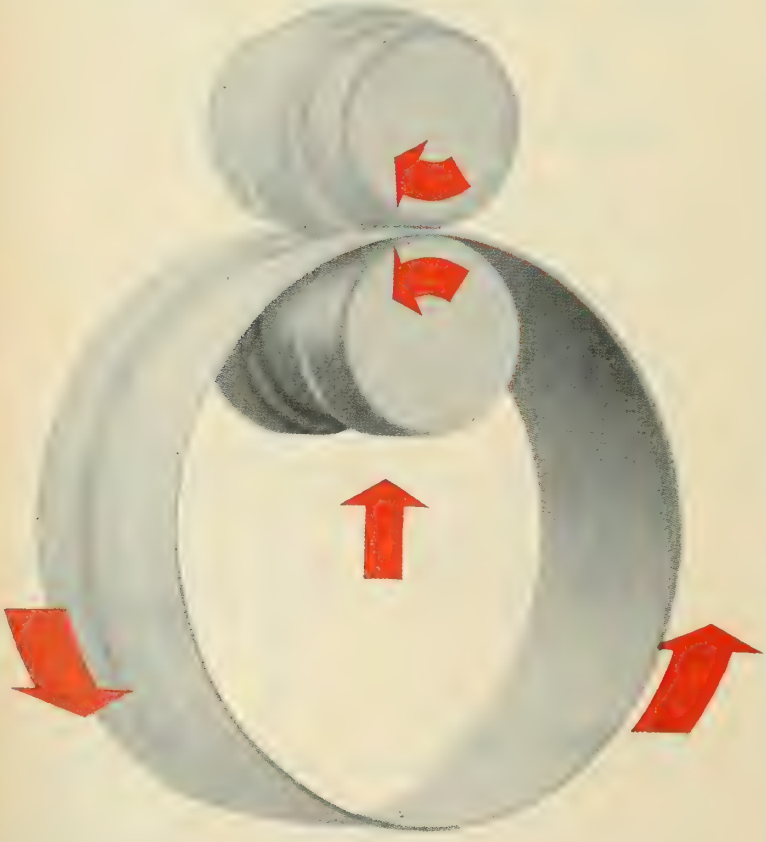
The hold-back mechanism can be fitted with dies or it can be used as a simple retaining surface. When forming beads, or when a combination operation is desired—shrinking and expand-



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Shrinking is directly opposite to expansion, the jaws being forced against the part by the descending ring, and is used where tolerances are critical.



Arrows show direction of rollers in forming a rim. Upper roller is fixed while lower one is actuated by hydraulically operated toggle linkage.

ing—corresponding dies can be fitted. An unusual feature of the expansion process is the tendency of stretched metal to spring back to its original shape. Though this action is minute it must be taken into account when setting the jaw travel. After the spring-back is calculated for a given metal and the jaws are set accordingly, all items processed with that setting are formed with identical OD and ID measurements, thus permitting mass production standards to be established.

By fitting the jaws and hold-back ring as noted earlier, a cylinder can be expanded to a square or a cone can be given a polygonic base. In fact, some of the combinations of shapes possible with expansion and shrinking are either impossible or impracticable using any other method. Because of the fact that the metal is processed cold, and that in most cases no machining is required, processing metal parts with the Grotnes Method and Grotnes machines is generally the most economical production standard available.

The question invariably asked is: "Where does the metal come from to allow for displacement in shrinking and expanding metal parts?" The answer supplied by the Grotnes Chicago office is sufficient of itself. It seems that the cold flow over the face of the dies in cold-forming allows the metal to be drawn from the entire body of the part, thus avoiding any local thinning or weakening. Amazingly, in such operations tolerances of no more than ±.002″ are maintained, a degree of accuracy which eliminates much costly additional processing.

The principle of shrinking is exactly opposite to that of expanding. In shrinking the jaws are forced inward by the action of a tapered ring or by toggle links. Shrinking is used where the amount of reduction in diameter is relatively small and where a higher degree of dimensional accuracy is demanded. Shrinking is often employed in conjunction with expansion, and as with expansion, shrinking is done with or without dies. A clear picture of this operation can be adduced by imagining the metal part being compressed by the action of a ring or mandrel being drawn over it.

Typical of the shrinker application is the reduction in diameter and sizing of the domed heads for compressed air tanks. Sizing is effected automatically to insure an inside diameter consistent with the cylindrical shell. Like the expanders the shrinkers lend themselves to a high rate of production.

The Grotnes principle, the company claims, can supply at least part of the answer to any problem of metalworking that might arise.★

Machining for Solid Propellant Rockets

cooperation between product engineer and hardware source can crack missile price barrier

By Joachim H. Kauffmann
President, Diversey Engineering Co.

THE MISSILE is a costly bird, particularly when you figure that despite all the love, labor and money that goes into it, just push the button once and . . . scrap! It's a throw-away item.

The taxpaying public has tolerated the high cost of researching and developing missiles with patience and understanding. The results, on the whole, have justified both patience and cost. However, whether either public or the economy will long stand for production missiles with research and development price tags is doubtful. The recent top-level AF missile cost symposium for major contractors is an example of the coming price consciousness. The desire for more missiles in less time for less money is becoming a national necessity.

In the case of certain vital components, such as rocket nozzles, forward domes, aft closures, adapter rings, accumulators and sometimes even nose cones, machining is often the only known practical means of obtaining the desired end product. Also, it's one of the costliest missile production processes. But costs have been cut in the past and, with proper cooperation between component supplier and end-product engineer, the missile price barrier will also be cracked.

Missile metal machining has progressed a long way since World War II. Technological advances in metalworking, machine tools and metallurgy have all played their part. But better methods breed more rigorous demands. Just as a manufacturer figures he's got a new and complex process down to a routine, along comes a rocket design requirement that demands closer



tolerances, more rigid specifications, more complex contours and a yet more awkward material to be machined.

Diversey Engineering Company now has contracts for machining parts for over fifteen major missiles including *Hawk, Titan, Sparrow, Falcon, Talos, Nike Ajax, Nike Hercules, Recruit, Lacrosse, Polaris, Deacon* and others. The missile materials the company works with include aluminum, magnesium, titanium, aircraft quality steels, nickel-cobalt alloys and molybdenum.

As with any component supplier, it is the responsibility of an engineering company specializing in complex machining to keep its processes and techniques not only up to the job, but on as low a cost basis as possible. It is also its responsibility to keep its market constantly aware of latest developments. Just as missile system research and development teams must propose and test, so must a missile machine shop experiment with and try to develop new and promising processes.

It was just such an effort that proved the full worth of the air tracer lathe—today's mainstay of missile metal machining. And it is just such a similar effort with hydro-spinning and hydroforming that will result in new design flexibility and production economy. Diversey has pioneered in both these fields and now has the largest single contract supply of Monarch air tracer lathes in the U.S.





Above: Four stages in the production of a solid propellant rocket nozzle—rough casting; rough machining; finish machining; threading. To the right, a solid aluminum billet begins to take shape as the core mold for fixing shape of solid propellant burning surface.

In the last eight years development of this equipment has put three dimensional contour tracing on a mass production basis, enabling the rapid repetitive machining of complex missile parts that would otherwise require costly, time-consuming hand work. Hydro-spinning shows particular promise in the production of rocket cones, nozzles and tubes.

To get an idea of the complexity of process and rigidity of specifications in rocket machining takes only a quick look at the quality control requirements imposed in a missile contract.

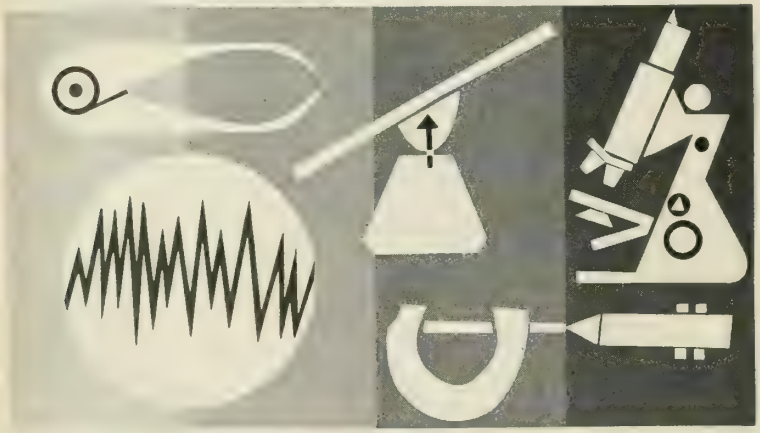
Each machined part has its own serial number coded to files containing as much inspection and process data as the health record of a VIP at a modern hospital. These cover material analysis, heat treatment of components, subassembling, magnafluxing, radiological and fluorescent dye penetrant inspection processes, hydrostatic testing and finally the bug-a-boo of all missile hardware: strict reliability.

These demands cause a veritable blizzard of metallurgical, quality control reports and certifications to accompany each component to the final assembly point. Precision inspection equipment for examining finish surfaces, contours and dimensions alone in such a plant as Diversey may represent a capital investment of $100,000.

The machining, for example, of one solid propellant rocket nozzle calls for a three dimensionally contoured wall of tapered thickness to be machined to an internal dimensional tolerance of ±0.001 inch and a surface finish of at least 32 microinch. In another case an accumulator's internal dimensions must be held to within +0.0005 inch, —0.0000 by machines designed for normal tolerances of ±0.001. And these machine tools are the best available.

The problems in machining rocket parts are varied. The major one is that standard straight line machining is not acceptable. Items of solid propellant motor hardware generally have one similarity—thin-walled contoured sections. This necessitates the employment of contouring machinery on a greater scale than in any other industry. Thiokol, Allegany Ballistics Laboratory, Aerojet-General, as well as other designers have this common requirement. Diversey specializes in satisfying these needs.

Solid propellant rocket hardware is not as varied as in the liquid engine



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field but has specific problems all its own. The major hardware items are: a cylindrical case, forward domes, aft closures, adapters and nozzles.

Nozzles are either bolted or screwed to the aft section of the motor case to facilitate the loading of the motors. The case assembly is either rolled and welded, deep drawn or of laminated construction.

The most commonly used alloy steel in this fabrication is electric furnace, aircraft quality 4130 (MIL-S-6758). This hardware with exception of nozzles is generally welded to the case. The whole weldment is heat treated to specifications which spell out yield and tensile properties or they merely specify a hydrostatic pressure test for specific time periods.

After heat treatment of the motor assembly, several surfaces must be remachined to assure alignment of the nozzle. Concentricity and squareness of these surfaces are critical and tight tolerances are spelled out. For example, concentricity and squareness of a typical solid propellant motor assembly might be as close as $\pm$.005 on concentricity over a 12 foot length and squareness and parallelism of .003 inches on all trued up surfaces. This is to be attained on a weldment.

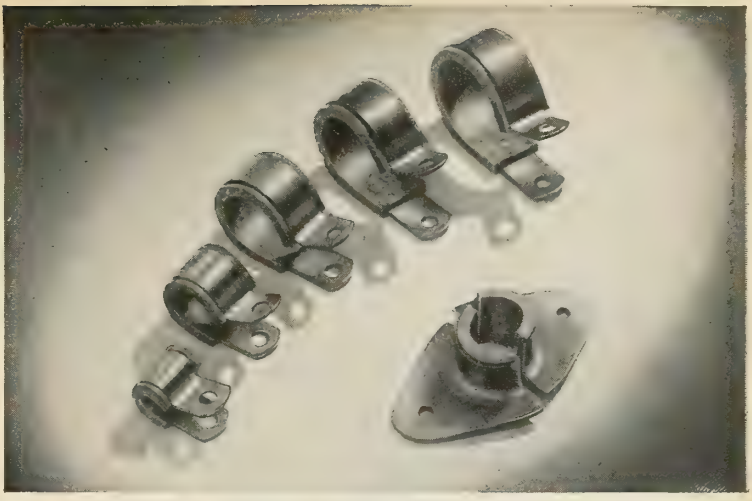
The problem is not so much doing these things, once or twice. It is the development of production methods that enable them to be done on a nearly automatic, repetitive, low cost basis.

Utilizing contour turning techniques permits the design engineer to cut his lead time from prototype to pre-production or production of a solid propellant hardware item. He has the time saving advantage of being able to specify all complex details on a single template, instead of being forced to delay machining until special form tooling, cams and checking fixtures are constructed.

The details are simply machined on a thin plate of good quality steel and can be checked in any modern inspection department, either by standard vernier and radius gages or by comparator. If the template is properly machined, the job is ready to run.

A typical example of this problem is a large, solid propellant motor adapter. The contours are complex, tolerances and surface finishes critical. To fabricate the part properly, it requires a forging designed to give optimum strength. The units are rough machined, using a roughing template in a tracer lathe, to a $\pm$.010 inch tolerance to control heat treating results. Finish machining is done in the hardened state to surface finishes as fine as 16 microinches and dimensional tolerances as close as $\pm$0.0005.

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turning principles and cutting tools, such as ceramic "throw-aways" and the harder carbides, superior finishes can be attained on modern, rigid lathes which are tracer controlled and can repeatedly duplicate difficult contours and sweeping radii to close tolerances.

In machining hardened missile components, exceptional results have been obtained on air-gage tracer lathes using ceramic tool bits, M-95 and K7H carbides. High velocity turning up to 1000 surface feet per minute—three times what steel is normally turned at —imparts excellent surface finishes ranging between 32 and 63 microinch, thereby eliminating costly grinding and polishing.

Manufacture of core molds for casting the solid propellant is a constantly expanding field. Long contoured tapers are milled on aluminum bars or extrusions in a variety of shapes such as star or cruciform configurations. Extreme care is needed to maintain concentricity along each of the tapered planes in order to ease the extraction of the core from the solid propellant. Generally, all cores are coated with Teflon or a similar substance.

The welding of solid propellant components must be rigidly controlled due to the fact that after welding and heat treating, the only machining that is possible on motor case assemblies and subassemblies are light finishing cuts to true up the axis of the case to the nozzle and to the adapter. Jigs for holding components during welding must insure the end product being as concentric as possible. Since all assemblies are subject to hydrostatic test and/or radiological inspection, welding specifications must be strictly followed.

Care must be taken in heat treating that a minimum of distortion takes place. Here again, due to the thin wall, uneven sections of solid propellant components, a thorough analysis must be made of each component prior to heat treating.

When considering production items from a cost point of view, design and engineering groups should work closely together to ascertain whether an investment casting out of the proper alloy steel can be used by simply machining out the area matching the external dimensions in the components and welding same in place. This can result in great savings in manhours, scrap and lead time.

In most instances this 5000-year-old "lost wax" casting process provides physical properties that meet design standards. It is entirely possible that it may prove as economical and useful in rocket motors as it has in turbine engines and other ordnance gear.

Actually, when a missile or rocket



Among the many requirements for heat elements in industry today are those demanding virtually one-of-a-kind design.

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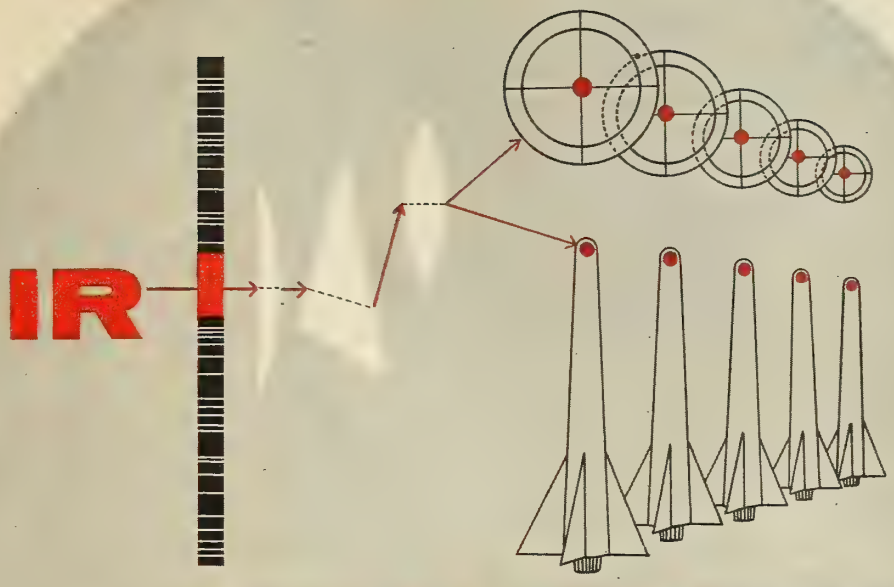
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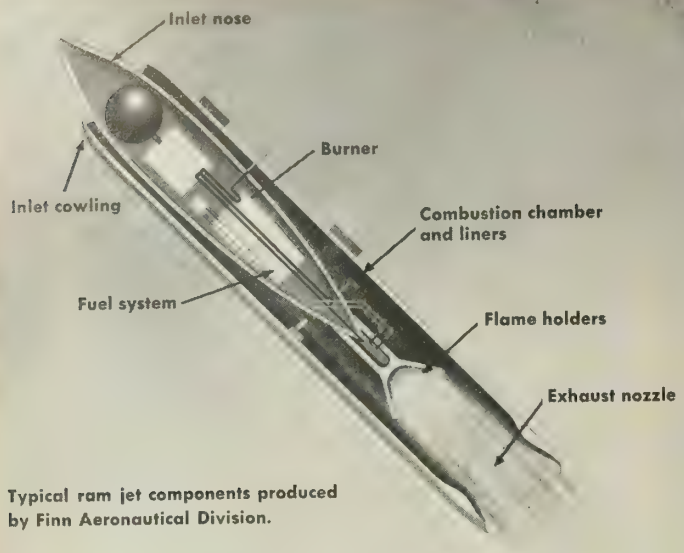
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motor is scheduled to go into production, all specifications and tolerances should be given a close second look. For example, is it necessary to pay the heavy premium of machining a rocket motor adapter to thousandths of an inch when it's going to be given a plastic liner accurate to hundredths?

When a missile is in the research and development stage, designers are worried primarily about making the *system* work. There may be a tendency to over-specify materials and tolerances in order to preclude failures due to simple mechanical failures. However, once the system is proved it may well be possible to ease specifications, particularly of individual components. Easing the preparations for machining and the material to be machined, minimizing tolerance — all tend to reduce machining costs. Molybdenum costs more to machine than titanium; titanium, more than steel; steel, more than aluminum, etc.

By machining one component, now in full production, out of an investment casting rather solid stock, per unit costs may be reduced from $800 a copy down to around $200. When the order entails thousands, this is a major cost factor. Considerable cost savings may also result when, say, the external tolerances and finish on an accumulator are eased. Wherever closer tolerances are called for, cost goes up exponentially.

This is the job of the production or process engineer. Its his task to design producibility into production missiles—to check every specification the design engineer calls for; to point out to him differences in costs of various materials, various production methods, tolerances, etc., vs. the difference in performance (if any). This is a vital phase of anything scheduled to go into production, missiles and rocket motors included.

Low Cost Hydrospinning

In this connection, hydrospinning may prove as useful over the next decade as the air tracer lathe is now. Hydrospinning is a cold process in which the work piece is forced to take the shape of a hardened rotating mandrel. Its great usefulness is in the manufacture of hollow symmetrical parts of tubular or conical shape, and is particularly advantageous where walls of varying thickness are required.

In some missile operations now requiring careful contour machining, hydro spinning will save 80 per cent in machining time and 50 per cent in machine costs.

The big plus, however, is in savings in material and time, increase in tensile strength and fatigue resistance and, in some cases, reduction in weight

as a result of cold working. In addition, an excellent finish is obtained on the inside surfaces. Outside diameter finishes are frequently satisfactory in the "as spun" condition.

During hydrospinning, the metal being formed undergoes shear deformation. Work hardening accounts for an appreciable increase in tensile and yield strength. Elongation is decreased proportionately. The process has many advantages in the case of cost cutting and mass production.

At present, cones with an included angle of 30° can be spun from a flat blank. This is a blank reduction of 75%. Lower degree angles can be obtained if the part is preformed. For cones of varying wall thickness, a premachined blank is required.

In the event contours other than those of parallel or angular size are desired, a contour attachment can be used to obtain the necessary shape. This combination of contour hydrospinning lends itself admirably to most solid propellant rocket motor parts.

For tube spinning, hydrospinning basically amounts to cold extrusion. Raw materials can be in the form of cold drawn tubing, hot rolled tubing, rolled or welded blanks or, in some instances, preforms machined from forgings. Because of the tremendous pressure applied, welding defects in welded blanks will show up as a defect in the surfaces of the tubing, thus providing excellent welding inspection. Maximum recommended wall thickness for the tubular blanks is ¾ inch. Some tubes have been spun with a reduction as high as 90%.

In regard to reliability, the missile hardware machining source must exercise strict reins on quality control. Top management must instill a feeling of absolute responsibility in all branches of the facility. Supervisory personnel, as well as machinists, welders, assemblers, testers and quality control personnel must be thoroughly briefed on problems to be solved, processes involved, high quality of workmanship, etc. The whole missile hardware plant must take the deepest interest in all operations. "The end items can only be as good as are the capabilities of the men that manufacture them. A feeling of pride and intense interest must prevail throughout."

As the solid propellant field widens, more unusual demands will be made on the hardware source. It is imperative that this source stays abreast of the newest developments in machine tools. Design, project and process engineers must be informed of these developments and urged to adapt their designs insofar as possible to manufacturing processes with optimum producibility.★

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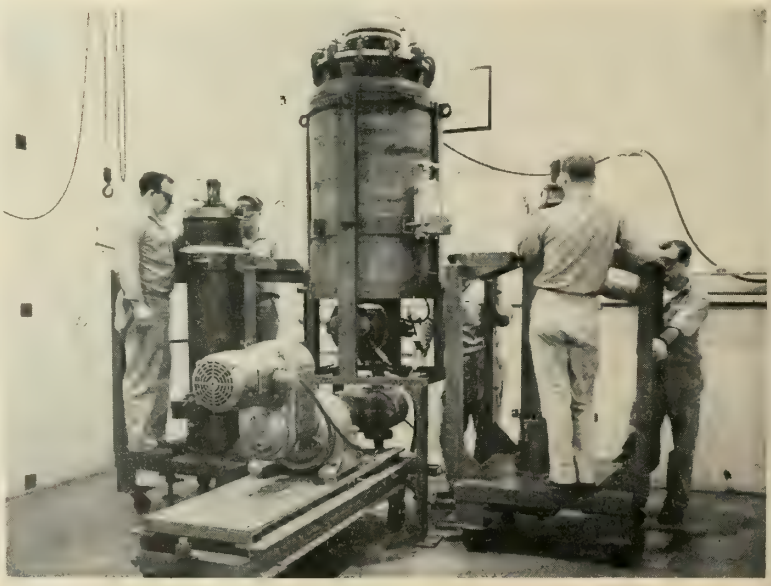


Vertical rocket motor test. The complete rocket motor is subjected to test firing during development (over a very wide rocket motor temperature range). Selective sampling of production motors is a major effort of the testing team. A vertical test pit and allied instrumentation surrounds the motor in this scene and only hot exhaust gases are shown.

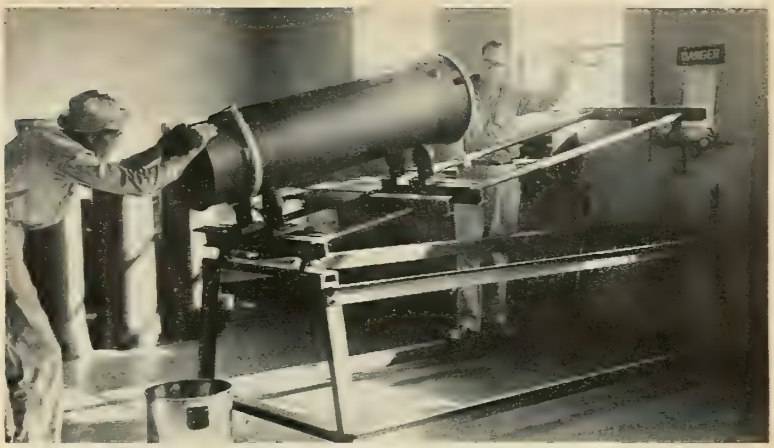




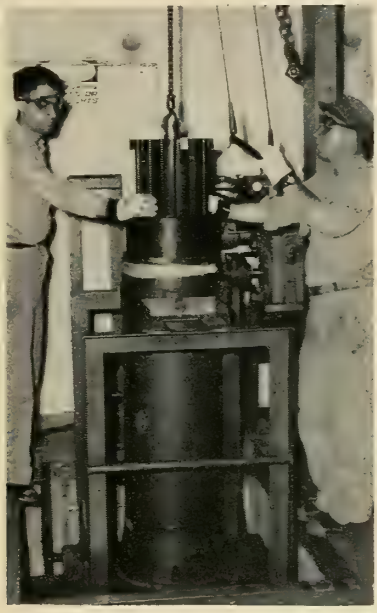
LEFT—Remote operation scene. A technician operates a machine from behind a revetment while viewing the operation through a port-and-mirror. RIGHT—Composite propellant mixer in a tilted position as used during discharge of the propellant from the mixer to the transfer can. The Baker-Perkins mixer accommodates about 1,400 lbs. of propellant. The mixer is jacketed and a heating fluid is used to control the temperature of the propellant during mixing.

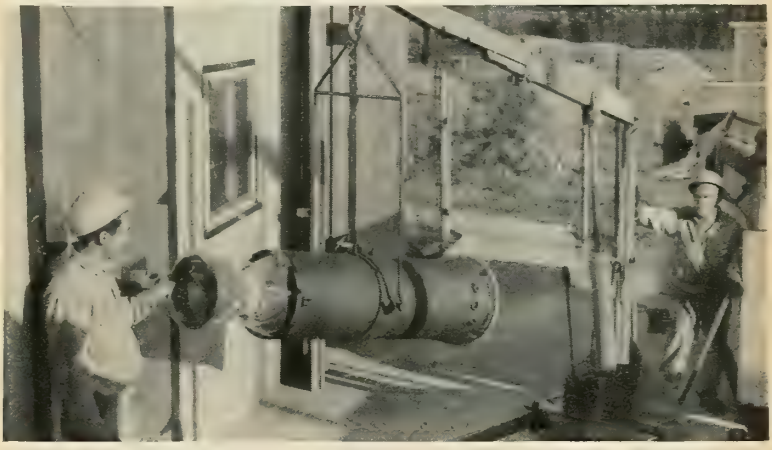


Propellant (polysulfide, composite type) in the raw state is pumped from the large transfer can into two rocket motors. At this stage the propellant is a very viscous fluid which flows into the lined rocket motor case. The loaded case will be placed in an oven to cure the raw propellant to a hard rubber solid that bonds to the lined case.



Rocket motor case being prepared for lining operation. Each case is first tested, inspected and cleaned. Liquid rubber made by Thiokol is then applied to the entire inside surface of the case and a thin layer of this lining rubber is cured. This thin layer bonds to the case and provides an excellent surface for later bonding of the propellant.





Transfer of a rocket motor from a temperature conditioning chamber to a test cell. Each rocket motor is conditioned to a known temperature prior to test firing thus eliminating one variable from the evaluation of motors during development. This procedure is also used to demonstrate the wide operating temperature range of which these motors are capable.

Removal of the core. A core is placed in the raw propellant prior to cure of the propellant. The core is subsequently removed leaving the desired internal cavity in the case bonded propellant. During burning the flame front progresses radially outward from the internal cavity thus the case is protected by the propellant from the hot gases.



The Army's most sophisticated tactical surface-to-surface missile, LACROSSE, leaves a searing flame in its wake during launch from White Sands Proving Ground. Flame is produced by one of the largest production solid propellant motors—an achievement of the Thiokol Corp. The motor's propellant has a synthetic rubber base, containing an oxidizer.

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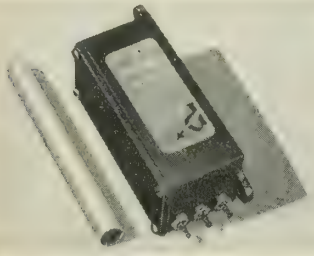
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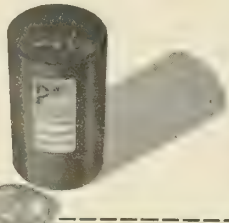




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electronics briefs

AC Spark Plug Developing *Regulus* Guidance System

A new type of guidance system for the Navy's *Regulus* missile is under development by the AC Spark Plug Division of General Motors, as well as a guidance system for the Martin *Matador*. Chance Vought Aircraft, builder of the *Regulus*, reports that the missile has already been checked out at altitudes in excess of 50,000 feet and at speeds of Mach 1.5 and above. The *Regulus* system is being handled by AC's Milwaukee plants.

Servo Corp. Builds *Sidewinder* System Tester

Testing and calibration of the *Sidewinder's* infrared detection system is done with an infrared radiation standard developed by the Servo Corp. of America. The Government and Industrial Division of Philco Corp. used the IR device to test the sensitivity of the lead sulfide cell, the heart of the *Sidewinder*.

Sidewinder, the Philco-Navy developed AAM for Navy fighters, is the first missile to successfully use the infrared homing system.

Radioplane Receives Army Target Contract

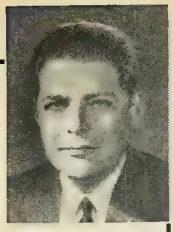
Radioplane Co. has been awarded a $4.5-million contract by Army Ordnance for providing target flight service to the Army's surface-to-air missile training program at Fort Bliss, Tex. One of the first of its kind to be awarded, the contract requires that Radioplane Company provide not only aerial targets and ground support equipment, but operational, training, and maintenance personnel as well. Field headquarters for the program will be at the Radioplane plant in El Paso, Tex.

Missile Master System Will Support *Hawk*

Missile Master, an electronic system for controlling and coordinating fire of *Nike* anti-aircraft batteries, will also be used to coordinate the *Hawk*, the low-altitude air defense missile, according to a recent Army announcement.

Missile Master is manufactured by the Martin Co. at interim facilities in Orlando, pending completion of the company's Orlando Division plant.

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Astrionics

By Henry P. Steier

"Our kingdom for a transistor," could be the next utterance of IGY scientists. Serious delays in obtaining enough camera tracking equipment for the satellite program are raising questions as to what it would mean if a satellite were launched without them.

Dr. John P. Hagen, Project *Vanguard* director said recently that we can go ahead safely with Minitrack alone. There must be something lost if the cameras don't materialize on time: It is the degree of accuracy with which data on the earth's shape, gravitational field, atmospheric density, etc., will be obtained.

Use of the cameras would add a whole order of accuracy to such data and new orders of accuracy are a prime goal of IGY work. If only a 1000 megacycle transistor were available the cameras might not be needed.

Minitrack's tracking accuracy limitations will be set by refraction of the satellite's 108 mc signals as they pass through the ionosphere. The angles from which the signals come will be "apparent" not real. Minitrack's designers say raising the signal frequency to 1000 mc would enable Minitrack to compete with camera tracking accuracy.

•

Results of six years surveillance of military electronics in the field have been published by Aeronautical Radio Inc.'s Reliability Research Department. The work should go down in history as a definitive study of unreliability and what causes it. If ever a study was conducted to highest scientific standards of observation and classification of facts this one was. In the face of much talk about unreliability and superficial treatment of it by many segments of industry, this work should, after a close study of its conclusions, be very convincing as a guide post to do something about unreliability, in all electronics work.

•

New rallying point for strolling satellite enthusiasts ought to be International Business Machine Corp.'s new *Vanguard* computer center at 615 Pennsylvania Ave., N.W., Washington, D.C. On one side the new building houses a most colorful display of gold-plated satellite, rocket engine, optical and radio tracking gear, and guidance devices. On the other is equally colorful IBM 704 computer that will keep scientists and the public posted on "how goes it." Not open to the public, the building was designed for sidewalk viewing. It's the newest addition to the "sights" in Washington.

•

Navy will soon give radio astronomy a field tryout on board the U.S.N. Compas Island to determine usefulness for navigation of missile ships and submarines. All weather position-fixing capability is needed. Pioneering work in the field of radio astronomy by Dr. John P. Hagen to codify radio signals from various stellar bodies may soon pay off as a new means of navigation. Navy says the large-antenna problem has been overcome and now antennas suitable for shipboard can be used.

•

If you see a *Moccasin, Rattlesnake*, or *Copperhead* missile name don't be surprised. It'll belong to the *Sidewinder* family of infra-red tracking missiles. We just learned from Dr. Alvin Novick of Harvard University that nature was way ahead of us on use of this tracking method. These snakes belong to a species known as Pit Vipers. On each side of the head between the nostril and the eye is a sensory pit. It houses a heat radiation detector that enables these cold-blooded creatures to track warm-blooded creatures at night. *Sidewinder* snake is one of this species.

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Space Medicine

by Hubertus Strughold, MD., PhD.

The following is a report covering the symposium on "Problems Common to Astronomy and Biology" held in Flagstaff, Ariz., June 18. The occasion was a joint meeting of the Astronomical Society of the Pacific and the International Mars Committee.

A paper by Lt. John A. Kooistra, Jr., Dr. Roland B. Mitchell, and the writer, dealt with the behavior of microorganisms under conditions simulating those of Mars. It attracted much interest among astronomers. In these experiments soil samples obtained from the Painted Desert in Arizona, and samples of lava, etc., with their inherent microflora, were exposed to a combination of lowered barometric pressure, altered atmospheric chemical composition, reduced moisture and low temperature as these conditions are found on Mars.

Preliminary results show that there has been a trend of the dominant micropopulation originally in the soil samples to change into a different type of population capable of surviving and multiplying under these conditions. Some of the microorganisms gradually disappeared from the original sample. The experiments represent a completely new approach to the question of life on other planets and to astrobiology generally.

At the same meeting Dr. Ingeborg Schmidt of the University of Indiana at Bloomington, a specialist in color vision, discussed the applicability of recent advances in physiological optics to astronomical observation. She included new data on color vision, night vision, contrast vision, etc.

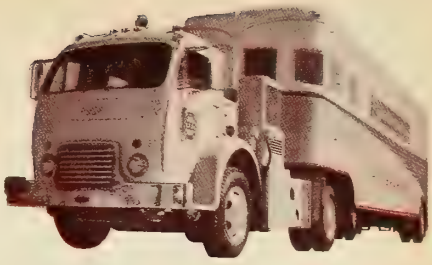
After the Symposium, color vision examinations were given by Dr. Schmidt. It is well known that about 4 per cent of the male population as a whole and only 0.3 per cent of the female population, are defective in color vision. These examinations attracted special interest because of the controversies extending over many years about the various colorations found on the planets. Of the 30 persons examined, six were color defective to a greater or lesseor degree. Information on these cases were, of course, kept confidential by Dr. Schmidt.

In another interesting paper, Maj. David G. Simons, USAF (MC) from the Aeromedical Field Laboratory at Holloman AFB, N. M., discussed the possible use of sealed gondolas in high-altitude balloons as astronomical observatories.

The International Mars Committee, with headquarters at the Lowell Observatory on Mars Hill in Flagstaff, will continue its work. Dr. E. C. Slipher, Director of the Observatory, is the Committee's Chairman. Dr. Slipher conducted studies of Mars during its oppositions in 1954 and 1956, at Bloemfontein, South Africa. (See his report in the National Geographic Magazine of September 1955.) Dr. Gerard De Vaucouleurs, noted French astronomer and author of the book "Physics of the Planet Mars," is secretary of the Mars Committee. He is now in Flagstaff.

The educational television series on Space Medicine has been completed. (As I have reported, the script is by Mr. Green Peyton, Chief of Information Services at the School of Aviation Medicine; the films are produced by the University of Houston; the series is sponsored by the Ford Foundation). In one of the last two films Dr. Albert G. Wilson, Deputy Director of the Lowell Observatory, is seen discussing conditions on other planets with regard to their ability to support life. In the final one, Major General Bernard A. Schriever, Commander of the Air Force Ballistic Missile Division, Air Research and Development Command, appears in a discussion of the human problems raised by satellites and missiles.

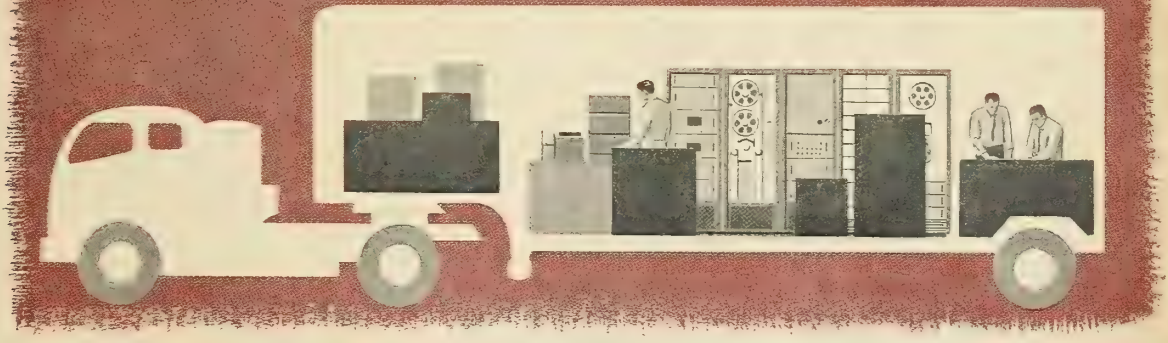
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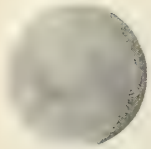
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Missile Miscellany

By 1/1/58, this page hears, solid propellants will be able to do anything liquids can (and more) with greater safety, readiness and reliability--all at less cost. This includes city-killer missile ranges up to 12,000 miles and large satellite vehicles. In fact, from propulsion viewpoint, new SPR mass ratios may obsolete Titan, Atlas, Thor, Jupiter overnight.

But then, National Bureau of Standards has produced atomic nitrogen and oxygen: possibly atomic hydrogen and the hydroxyl ion. Made at 2450 megacycles, they are stored at 4.2°K by molten helium. So goes the see-saw.

Add the Navaho demise, White House missile ire, etc., and signs are many that the young, precocious, expensive missile industry is heading for a jolting shake-out. While some companies will fall, stunned and flattened or wholly shattered, others will rebound vigorously from reality's hard floor. And the missile business, emerging from the remains of the aircraft industry, will headline new names among the old. This page figures the future's for those who stick to facts; that for those who would cite fact and fiction as one, tomorrow will be rough; end early. And speaking of facts, like dates, those who have reason to fear the first shake should beware the ides of October.

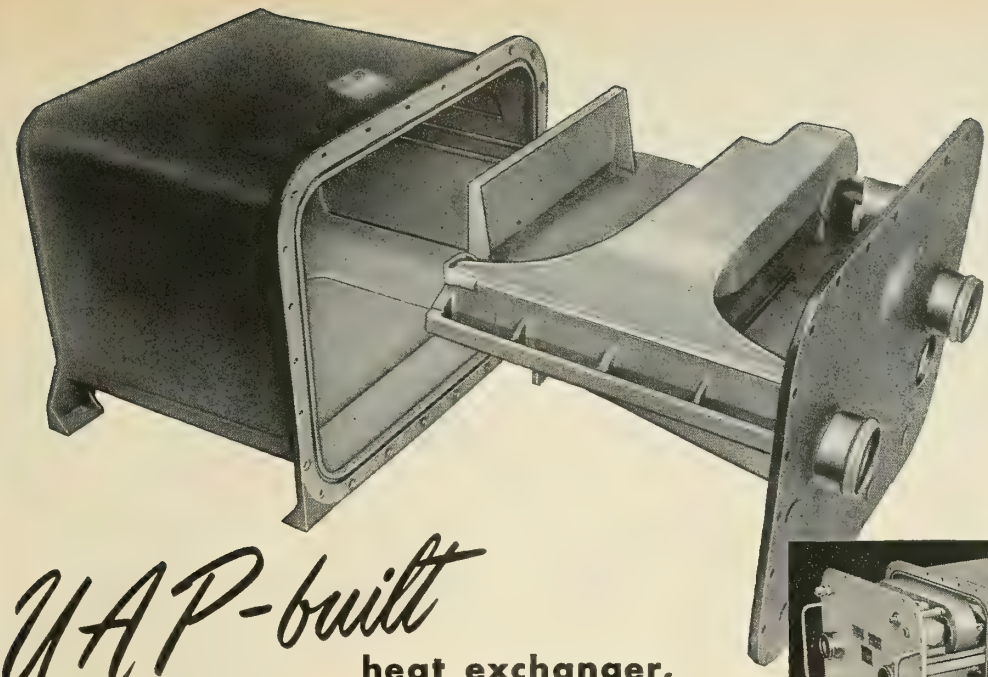
All of which goes to a bit of morning coffee philosophy: Namely, that the missile industry cannot long survive based on the premise that (apologies to P. T. Barnum) "a taxpayer is born every minute!"

And as a further sign of the times, other groups similar to Omar (Olin-Mathieson, Marquardt, Reaction Motors) are forming. Their avowed goals: Take missile business away from the aircraft industry; develop civil uses for rockets. Their means: Production knowhow. Watch their stocks.

In contrast to $269 million in reentry nose cone development contracts to GE and AVCO, this page recently heard a Wilmington company claim it can meet the need with ease and inexpense of a potter spinning soup bowls. An NACA-tested 1/2-inch thick disc of its material failed to disintegrate or crack under 20-second blast of 12,000°F plasma jet.

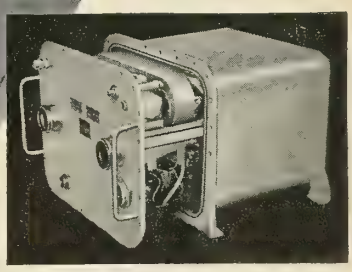
And back to a favorite subject: What happens to a sub-critical mass of plutonium that's accelerated to relativistic velocities? And another: Why won't heat flow faster when the potential difference is greater?

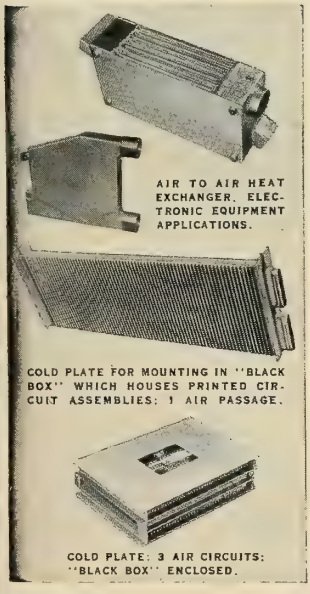
Lest we forget, missiles are a tough business as witness accelerations of plus or minus 40 G's at frequencies up to 600 cycles imposed on missile body by Snark boosters . . . And from the University of Dayton word of work on a reentry test vehicle . . . A rumor that AF may do operational testing of big missiles with nuclear warheads from Pacific coast because of danger of clobbering South Atlantic friends and possible fact Soviets have Florida range better instrumented than AF . . . Suggestion that wherever they're tested, some insurance company might do well to sell anti-missile insurance to those in line of fire . . . Plans for inertial guidance in airliners and FBM-launching submarines contrast with German use of inertial systems in WW I submarines . . . Russia's studying compatabilities of isolated pairs of men and women in arctic experiments--Adamsky ee Evesky on Mars maybe? Dr. H. C. Urey wants to chip study chunks off the moon with nuclear warheaded missiles . . . Smithsonian Astrophysical's Dr. T. E. Sterne figures life of 200-800-mile high satellite at nine years . . . If he gets job here, Dr. Hermann Oberth may cancel his return to Germany . . . Add Danes and Norwegians (but not m/r's exec-ed.) to those taking missile courses at Huntsville . . . Residents of San Fernando valley have timed Rocketdyne engine tests up to two minutes . . . To the right: One way to get ultra-long burning times for solid propellants in minimum length . . .



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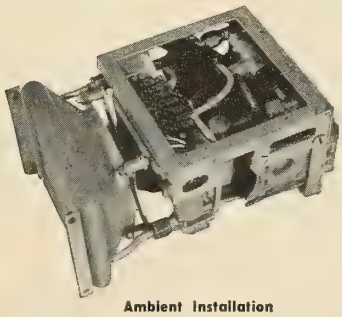
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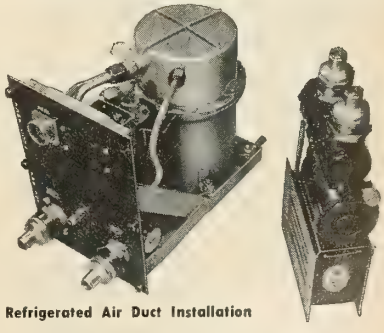
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INDUSTRY SPOTLIGHT

By Norman L. Baker

Thiokol Geared for Solid Propellant Business Boom

ELKTON, MD.—The Thiokol Chemical Corp. may well play the lead role in the military planners increasing emphasis on solid propellants for missile propulsion units of the future. The list of the nation's operational missiles gives Thiokol an impressive lead as supplier of solid power plants.

Lockheed apparently has released a contract to Thiokol for the initial testing of the powerplant for the Navy's Fleet Ballistic Missile, *Polaris*. Largest solid propellant missile officially revealed the *Polaris* will have a thrust of about 300,000 lbs. Reportedly Thiokol was selected for the testing phase of the *Polaris* motor development because of its advanced state of the art in developing large high-thrust solid propellants. This further indicates that Thiokol has been pioneering work in the high-thrust field for some time.

Significant is the fact that this work may have stemmed from the *Big "B"* ballistic missile program (m/r July 57, p. 48). Reported to be a 2000-mile Army missile powered by a Thiokol solid propellant motor its thrust rating would be comparable to the *Polaris* propulsion unit. A companion project, *Little "B"*, 750-mile ballistic missile, also will rely on Thiokol for powerplant development.

First flights under the Air Force Office of Scientific Research space program, Project *Far Side*, scheduled to begin this fall, will utilize a multistage solid-propellant rocket configuration. The motors, classed as off-the-shelf units, will be provided by Thiokol and Grand Central. *Recruits* will form the four-barreled first stage. A single *Recruit* will make up the second stage. Third and fourth stages will be modified *Loki* rockets. The fourth stage rocket will be nestled within the package of the four-rocket third stage. *Recruit* power plants are produced by Thiokol while the *Loki* is a development of Grand Central.

Thiokol's solid propellant development history can best be summed up in a list of existing operational missiles. The diversified program required to provide propulsion units for these varied weapon and research vehicles is quickly apparent. The motors range from boosters for the *Matador* and *Goose* to sustainer motors for *Falcon, Nike Hercules, Lacrosse, Terrapin, RV-A-10, Cajun, Recruit, Sergeant, Polaris, Big "B", Little "B"*, and the rocket motor for the new RESCU *Mark I* rocket ejection seat catapult.

Continuing research at Thiokol is conducted in the fields of propellant processing, manufacturing techniques, case-liner-propellant bonding, new material research for case fabrication and new propellant applications. Propulsion units developed at Thiokol range from "thimble-size to those limited only by practical mass-ratio values." Usually, as the size of the motors increase, the weight of the casing also increases until the mass-ratio value makes the design impractical. The search for new materials such as titanium and plastics is a continuing effort of the research team.

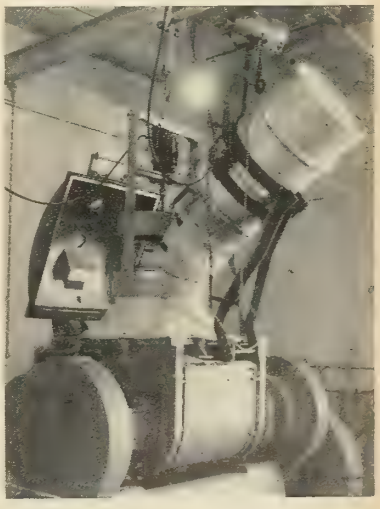
To the question of possible solid-propellant ICBMs, a company spokesman answered, "The development of a missile of the magnitude required for an ICBM is well within the realm of feasibility at the present time." This indicates a major reduction in the weight of the casing, a technical breakthrough which could very well mean the elimination of the size-limitation of solid rockets.

A major contribution to the field of solid propellants is the "case-lined cast-in-place" composite fuel mixture, a pioneering effort by the Thiokol Chemical Corp. With this system the composite fuel mixture is cast into place as a liquid and allowed to solidify. This permits bonding of the fuel charge directly to the internal walls of the pressure chamber. Insulation or cooling of the chamber casing and weight of supports is eliminated. Since the burning progresses from the interior toward the chamber wall, the chamber is protected from the heat of combustion by the propellant itself.

The elimination of the weight of inert components and utilization of a lighter, thinner engine chamber resulting in higher mass ratio values, makes the case-lined cast-in-place solid propellant adaptable to high performance systems. Thiokol's case-bonded composite-type propellants are readily adaptable for such an application. This is the determining factor for their apparent lead in the present emphasis on solid propellants for missile weapon systems.

The composite propellants produced by Thiokol are formulated principally of a polymer manufactured by Thiokol, an oxidizer salt, and a small percentage of chemical additives. The dry oxidizer and the polymer are dumped into a mixer by remote control. In the meantime a liquid layer of rubber is applied to the inner surface of the rocket casing and cured. This rubber acts as a bonding agent between the case and the propellant.

When the propellant has been thoroughly mixed it is discharged to a transfer can for the casting operation. The mixture is pressure-pumped from the transfer can into the rocket casings. The mixture is very viscous during this phase of the processing. A core, designed to form the internal configuration of the burning surface, is inserted in the raw propellant. The package is then cured in an oven until the mixture



Dry oxidizer salt is mixed with a Thiokol polymer. Mixing operation is by remote control.



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reaches the solid rubber state. The propellant is ready for trimming for the attachment of the rocket nozzle after removal of the core.

The discovery and development of Thiokol synthetic rubber by Dr. J. C. Patrick during the 20s led to the formation of the Thiokol Corp. in 1929. In 1941 a plant was installed at Trenton, N. J. for production of a solid polysulfide synthetic rubber and by 1945 this plant was marketing the basic component of Thiokol propellants, a polysulfide liquid polymer.

Thiokol currently operates six plants and laboratories: Main Offices, Trenton, N. J.; Redstone Division, Huntsville, Ala.; Elkton Division, Elkton, Md.; Longhorn Division, Marshall, Texas; Chemical Plant, Moss Point, Miss.; the Utah Division, Brigham City, Utah.

The Elkton Division was the first to undertake research and development on solid propellants and JATOs under contract with Army Ordnance. Main rocket activities were transferred to the Redstone Division in 1949. Research and development on industrial products are carried out at the main plant in Trenton. The facilities at Redstone and Elkton concentrate on rocket research for the Armed Forces. Although some production work is handled by Redstone and Elkton, the major production effort is at Longhorn.

The Utah Division, latest expansion achievement, recently began test operations. The new test stand at Utah will accommodate motors up to 12 feet in diameter and resist a two million pound load. The testing section is the first major portion of the facility while rocket motor mnaufacturing will commence this fall.

Thiokol employs over 2500 people, over 300 of whom are chemists, chemical engineers, mechanical engineers, mathematicians and physicists.

RMI Expands For Solid Propellants

Reaction Motors, Inc. has announced creation of a separate department for handling solid propellant fuels. Designated the Applications Engineering Department for Solid Propellant Rocket Power Plants, the new department will be headed by William M. Davidson and will be responsible for the development of new business in the field of solid propellants.

RMI's reorganization points out the growing trend in the industry toward the solid propellant fuels. This is the first time in RMI's history that a separate department for solid fuels has been set up, and it reflects the com-

pany's interest in this phase of rocket fuel development.

In the six months since the Institute of Aeronautical Sciences meeting heard speakers deplore the lack of exploitation in the solid propellant fuel field, there has been a distinct trend toward utilizing the fuels to a greater extent. Previous reluctance was laid to reliance on performance figures based on black gunpowder rockets. Judging by RMI's move and those of other producers of fuels, this is no longer true.

Mathieson Plans Propellant Expansion

Olin Mathieson Chemical Corp. has announced a four year expansion program to increase their facilities for developing and producing high energy, solid propellants. New R&D laboratories, pilot plants, and test and production facilities will be constructed at the company's Ordill works, near Marion, Ill.

The program at Ordill will involve the development of new propellants and new processes for the production of propellant grains for rocket engines. The company also plans to expand its development and production of gas generators for auxiliary power units on jet engines and missiles. In addition, it will cast double-base propellants which involve Mathieson's "ball powder" techniques and composite propellants for rocket engines in missiles.

These expansion programs are part of Mathieson's general plan to increase all their research, development and production in the broad field of fuels and propellants. including the new high energy chemical fuels. Two plants for the production of "zip" fuels are already under construction in Niagara Falls. The current program marks the company's first major effort in the field of solid fuels for rocket engines.

Rocketdyne Operates Vacuum Wind Tunnel

Rocketdyne engineers are now using a wind tunnel that pulls high speed air through a vacuum to simulate conditions at extremely high altitudes. The vacuum wind tunnel will be used in probing the performance of rocket engines and testing their components at these altitudes. The tunnel, located at the company's Los Angeles plant, is one of the first designed for high altitude rocket study.

In the tests, compressed air will be released in a supersonic rush through scale models of rocket engine thrust chambers resembling the narrow waist and flare of a hoop



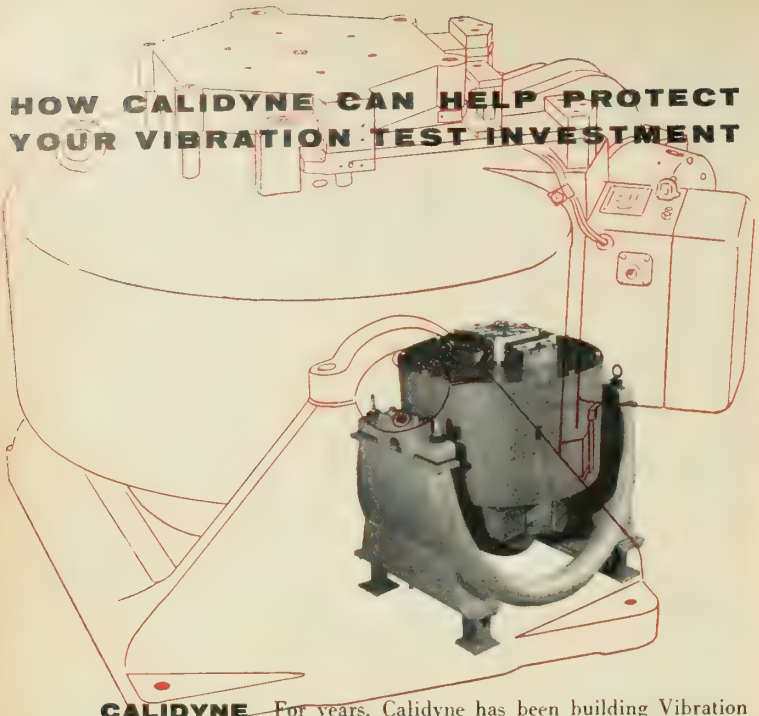
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skirt. To duplicate the upper atmosphere, the two-foot-wide testing chamber of the tunnel will be maintained under a partial vacuum adjusted to varying altitudes.



Final instrumentation check-out is made on rocket engine thrust chamber in test section.

Aerojet Sets Up Astronautics Lab

Aerojet-General Corp. has set up an Astronautics Research Laboratory to study advanced propulsion systems, astrophysical chemistry and materials. The laboratory's propulsion section expects to work on research involving ultra-high-energy chemical propellants, ion propulsion systems, gaseous free radical propulsion and nuclear plasma propulsion systems. In addition the lab will study all systems capable of high velocity extra-terrestrial flight. Director of the lab will be Y. C. Lee, Aerojet Director of Research, and Milton Farmer, Associate Director of Research.

Convair Occupies *Atlas* Production Plant

Convair-Astronautics has begun moving into its $40 million plant for the production of the *Atlas* ICBM. The plant, located on the northeastern outskirts of San Diego, is expected to be completely occupied by January. Moving plans and final construction plans were coordinated to afford a minimum of work interference on the missile, which is now in pilot production.

More than 7000 persons will be shifted to the plant. The million-square-foot plant will replace Convair's San Diego facilities as the headquarters of Convair's *Atlas* program.

The engineering lab will be the first section to be occupied, followed

by the office and reception center buildings. The factory building is scheduled for full use by mid-January. Total cost of the plant and its equipment will exceed $40 million, divided almost evenly between Convair and the Air Force. Convair is paying for the land, buildings and some of the equipment, with the AF providing most of the heavy equipment, including machine tools.

Chrysler Lists 1300 *Redstone* Subcontractors

The Army's prime contractor in the *Redstone* Ballistic Missile system, Chrysler corp. has compiled a list of vendors from whom purchases have been made during the program. The list is said to name over 1300 firms in the U.S. from whom purchases were made for the production and research and development phases only. There are a total of 1675 vendors in 34 states and the District of Columbia.

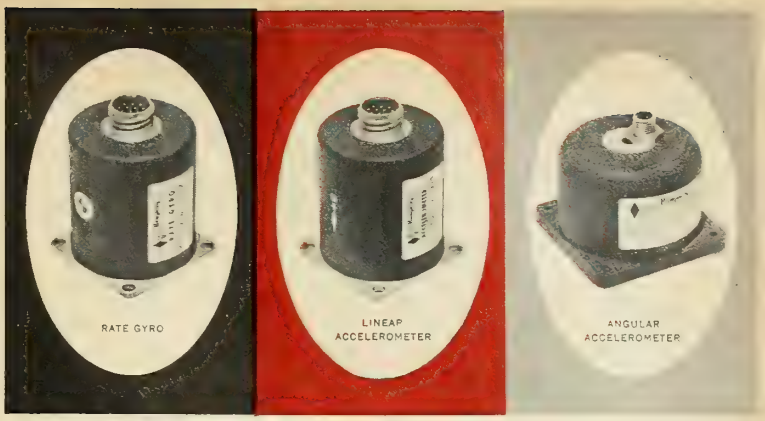
Chrysler's breakdown of the figures show that: 811 of the firms, or 48.4% employ less than 100 persons; 519, or 31% employ from 100 to 500; 121, or 7.2%, employ from 500 to 1000; and 224, or 13.4%, employ over 1000 persons. Since "small business" is usually defined as those employing under 500 persons, the actual number of such vendors is 1330 or 79.4%.

AC Spark Plug Receives *Thor* Guidance Contract

AC Spark Plug Division of General Motors has been awarded a $38-million contract from the Air Force for research, development and production of the inertial guidance system for the IRBM, *Thor*. Authority to begin work under the contract was given some months ago by the Ballistic Missiles Office, Air Materiel Command, which awarded the contract.

GE Gets Contract For Reentry Nose Cones

General Electric's Missile and Ordnance Systems Department in Philadelphia has been awarded a $158-million contract to develop nose cones for the *Atlas* ICBM and the *Thor* IRBM. The company's Nose Cone Section, under R. W. McFall, is staffed by 2000 people engaged in research, systems engineering, design engineering and development manufacturing of the nose cone.



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LINEAR ACCELEROMETER is of dual contra-rotating mass design. It has practically zero sensitivity to cross acceleration and angular acceleration; ±symmetrical or asymmetrical ranges (0 to 1G) to (0 to 100G).

ANGULAR ACCELEROMETER is compactly designed with completely symmetrical inertial ring. Available ranges are from zero to ±½ rad/sec² to zero to 100 rad/sec.² Except in very low range, either potentiometer or inductive pick-off can be furnished. Performance for either instrumentation or control systems is excellent.



Rate Gyro—Model RG15-0102-1: New simplified design with light-weight efficient motor.



Linear Accelerometer—Model LA15-0501-1: Zero sensitivity to cross and angular acceleration.

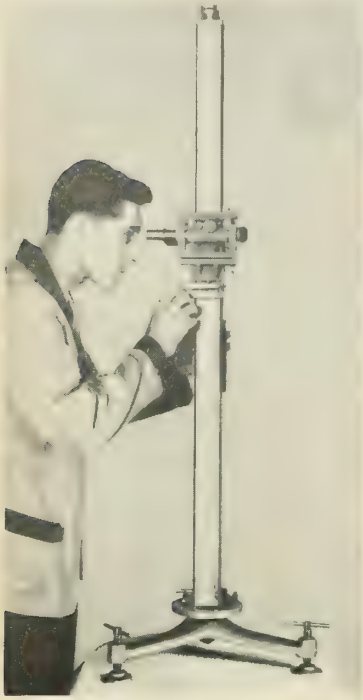


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West Coast Industry

By Fred S. Hunter

"First *Atlas* Ends in Failure" is the way the headline read in a widely-circulated national magazine. Well now, let's see! What, actually, constitutes "failure" in the test firing of the prototype of a new missile? How do you define it? Matter of fact, if you learn anything at all from the test firing of an experimental missile, can you call it a failure?

If something starts to go wrong on the first flight—or any test flight—of a manned aircraft, there's a pilot aboard to bring the airplane back to the hangar. Occasionally, a test pilot has to bail out, but normally he's able to return to base and continue the test program with the same airplane after fixes are accomplished. By contrast, if a missile starts to wobble, there's no alternative but to blow it up. You don't get to bring it back and use it again.

Where do you draw the line of "failure." We're reminded of the news writer who coined the phrase "*Snark*-infested waters" in describing Northrop's troubles with early XSM-62s in Florida. Northrop lost 13 experimental *Snarks* in these early tests. Now, successful *Snark* flights have become commonplace over a 2000-mile range in the Atlantic. The missile's reliability is one of its stronger points. How did Northrop accomplish this? Through the things it learned from the 13 losers. Would you say they were failures?

•

With the Air Force dropping North American's *Navaho*, what happens now to Wright Aero's ramjet engines? The *Navaho* was the only vehicle for which these particular engines were scheduled. But not many ramjets are in the works and the Air Force might consider an R&D contract for continued development advisable. Moreover, the Wright engines are big ones—48 inches as compared to 28 inches for the engine developed by Marquardt for the *Bomarc*. The Wright ramjets never reached flight test in the *Navaho*. It is understood that in one XSM-64 test, they were ignited momentarily at about Mach 1.5, but this wasn't fast enough to keep them going.

•

North American's new general office building in El Segundo is on the route over which Northrop trucks *Snarks* from Hawthorne to the Los Angeles International Airport for loading on Air Force C-124s, and all Lee Atwood and Larry Waite have to do is look out the windows to count their competitor's deliveries.

•

Air Force's announcement that General Electric's $158-Million nose cone contract covers both the *Atlas* and *Thor* missiles would seem to be fair evidence that the Douglas IRBM is still in business and should set at rest rumors that it's shaky. Avco's contract for the nose cone of the *Titan* came to $111 million. It doesn't necessarily follow that the same dollar amount of GE's contract applies to the *Atlas*—it might even be less—but it isn't unreasonable to use it as a measurement and this would leave $57 million of the GE order for the *Thor*. Whatever else may be said of the *Thor*, it certainly is the "quickie" of all the ballistic missiles. Douglas had the first article on the pad within one year's time.

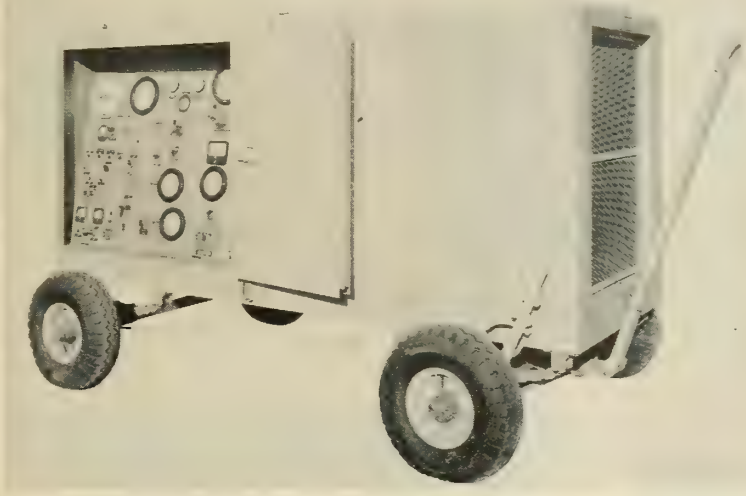
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Rocketdyne estimates two-way radio systems installed in eight trucks operating out of the Canoga Park plant enable present equipment and personnel to accomplish about a third again as much work.

NEW MISSILE PRODUCTS

MISSILE CHECK-OUT UNIT

A portable hydraulic power supply unit, designed by Haskel Engineering and Supply Company, serves as a source of high pressure hydraulic power for guided missiles requiring precise circuit check-out prior to launching. Designed for use with OS-45 high-temperature synthetic hydraulic fluid, the power supply contains two independent hydraulic circuits with a capacity of 20 gpm and providing pressures up to 5000 psi.



The unit is designed for remote control for personnel safety and its two circuits are both overheat and back-pressure controlled to shut off pressure and return in either circuit in case of excessive heat or back pressure. These controls also provide for dumping the pump output back into the tank and it is not possible to re-energize either circuit until the source of trouble has been corrected. Indicator lights are provided to locate the trouble.

The system features automatic pre-fill and bleed of the hydraulic circuits and is provided with a nitrogen purge pressurization system to preclude the possibility of contaminating the fluid. An automatic control is provided for the air type heat exchanger to maintain proper fluid temperature. Flow indication, system selection, on and off operation and emergency shutdown can all be achieved remotely. The unit is mounted on roadable running gear using light-weight Air Force Arctic tires. The cooling system, electrical system and piping can be serviced from separate access doors.

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COUNT RATEMETER

Nuclear Measurements Corp. has introduced its manual range changing linear



count ratemeter, model CRM-11. The instrument detects radioactivity sensed by GM, scintillation and proportional counting detectors. It is equipped with six linear scales, ranging from 0-300 C/M to 0-300,000 C/M. Dimensions are 22 x 15 x 10½ inches.

Circle No. 212 on Subscriber Service Card.

POWER AMPLIFIER

Rheem Electronics Division has introduced a new power amplifier for use



in airborne telemetering systems which is available in 17 configurations. Designated the REL-09 RF Power Amplifier, the unit is a single package containing volume, connectors, filament voltage and cathode bias, varied to extend the range of application. The product weighs 16 ounces.

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INSULATING VARNISH

Lynn Engineering Co. is distributing an insulating varnish capable of withstanding temperatures from —55°C to 250°C, and which is unaffected by gasoline, oils (including ester oils), alcohol, jet fuels, moisture and fungus. Known as Ulti-Meg 110, the varnish is suited for use on high speed rotating machinery and to all types of equipment subject to severe vibration. The chemical reaction of the product is completed during the baking cycle, producing a molecule which is physically and chemically stable and retaining its insulating qualities indefinitely.

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SMALL POWER UNIT

Rheem Electronics Division has developed a special miniature power supply for missile telemetry applications. It provides one unregulated high voltage output, one regulated HV output and a 6.3 volt heater supply. The unit is constructed for maximum reliability under environmental extremes.

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CERAMOPLASTIC RADOME

A new molding material for radome manufacture is being produced by Mycalex Corporation. Called "Supramica 555", the material withstands temperatures as high as 950°F. The ceramoplastic contains platelets of synthetic mica to act as "crack stoppers" holding the

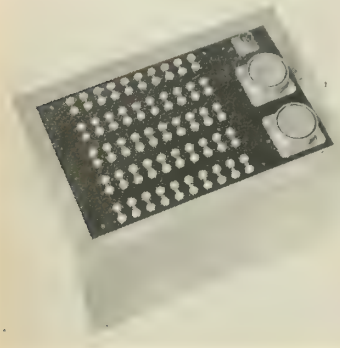


material together even when cracked. Molding tolerance in wall thickness of ±.005 "can be achieved, as well as machining tolerances of ±.001". The manufacturer anticipates that the thermal endurance of the material will be satisfactory at speeds as high as Mach 3.5.

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THERMOCOUPLE JUNCTION

Pace Engineering Company is manufacturing its BRJ Series of bridge stabilized thermocouple reference junctions providing controlled temperature reference for multi-channel thermocouple measurements. The unit has precision beyond the capabilities of ice baths and cold junction compensators now in use. Up to 48 channels are available in cabinet or rack



mounted models, as well as three-wire junctions allowing a choice of thermocouple materials in each channel.

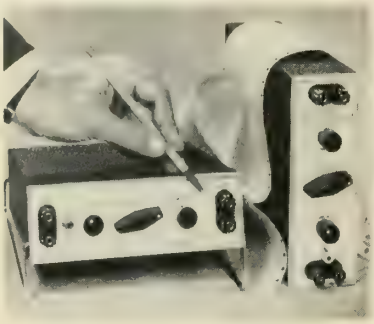
Long term temperature stability within 1/5°F is achieved with an integral resistance bridge temperature sensing system and magnetic-amplifier controlled heater. The reference temperature may be set to any specified level from 25° above ambient to 250°F and thermocouple tables are available for the standard reference temperature of 150°F.

Several models are offered with a variety of input arrangements and output coupling, thermocouple types and number of circuits. The reference junction is also furnished as part of an integrated control and calibration system for oscillograph recording. The unit's weight is 25 lbs., and it measures 10 x 10 x 15 inches.

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TRANSISTOR AMPLIFIER

A completely transistorized electronically modulated DC amplifier for use with milliammeter recorders has been introduced by Texas Instruments Inc. The amplifier has a sensitivity range from 10



millivolts DC to 100 volts DC full scale in 12 ranges. Frequency response is up to 50 cps. Specifications on the model 301 are: 7½ x 10 x 2½ inches; 4¾ lbs.; input impedance is 2.5 megohms per volt; output impedance is 39 ohms and absolute accuracy is 2% of full scale.

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BISTABLE DIODE

Shockley Semiconductor Laboratory has produced a new type diode. It is a low-power four-layer switching diode. The



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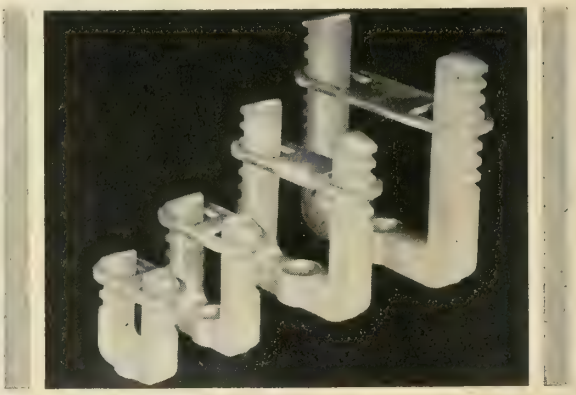
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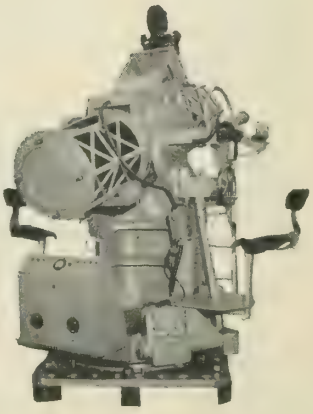
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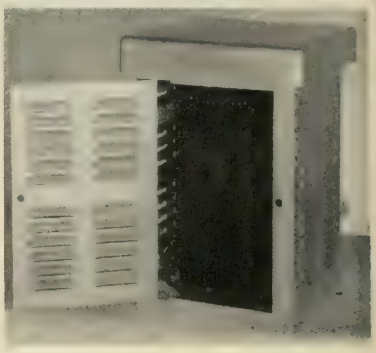
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about one volt; switched current capacity of 100 ma; maximum power dissipation of about 100 milliwatts; and switching rates of about 1 mc.

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REDESIGNED PREAMPLIFIER

A new weatherproofed and pressurized preamplifier design is announced



by Nems-Clarke, Inc., for use with telemetering receivers. The company says line losses as high as 6 db will not decrease the sensitivity of the receiving system by more than a few tenths of a db. The pass band has a uniform response of 3 db over a frequency range of 215-245 mc. The unit has a self contained power supply controlled from a 1¾" power control panel mountable in a relay rack with other receiving equipment. Similar units are available in the frequency range 225-260 mc.

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WAVEGUIDE PRESSURE WINDOW

A new waveguide pressure window for half-X waveguide applications has



been developed by Microwave Associates. The window (MA-1339) covers the frequency range 9.5 to 10.1 kmc with maximum VSWR of 1.10 at the band edges. Resonant frequency is 9800 mc. It is used in .2 x .9 ID waveguide applications. Maximum power rating is 20 kw. Maximum pressure handling capability is 45 lbs. on the glassed side of the window and 30 psi on the opposite side. Window construction is of kovar and glass.

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people

Dr. Joachim W. Muehlner has been appointed a consulting scientist in Lockheed Missile Systems Div.'s research and development branch at Palo Alto. **Dr. Muehlner** was technical director of the range instrumentation development division, Army Ordnance, at White Sands Proving Ground for more than five years. before joining Lockheed.

J. Y. Cunningham will head the new Missile Development Division organization at North American Aviation, which has just been separated from the Los Angeles Division. Other appointments in the new division are **R. M. Stronks,** manufacturing supt.; **Fred Burry,** general supv. of manufacturing services; **Harry Armour,** general supv. of missile planning; **D. F. Ziegler,** general supv. of missile tooling.

The new development planning staff at Fairchild Guided Missiles Division will be headed by **Harry Iddings** who was formerly associated with Cornell Aeronautical Laboratory.

Albert E. Schwerin, manager of Flight Test Engineering for General Electric's missile and ordnance systems department, has been assigned to the Air Force's Missile Test Center. He will head up his department's test activity at Patrick Air Force Base.

Lt. General Laurence C. Craigie (USAF, ret) has been elected to the Board of Directors of the Associated Missile Products Corp. **T. Rogers McNamara,** of Hughes Aircraft Co., has been appointed accounting manager of the corporation.

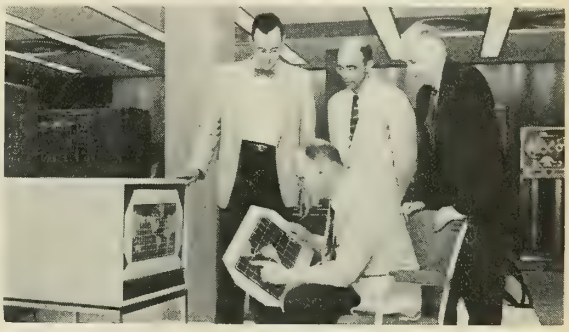
Dr. Michael Markels, Jr., formerly manager of heat transfer operations, Columbia University Heat Transfer Research facility, has been appointed to head Atlantic Research Corp.'s nuclear activities.

Willem Schaafsma has been named director of projects for the Grand Central Rocket Co. **Stanley Waxman,** former director of R & D, succeeds Schaafsma as director of engineering and research.

Wilfred E. Walton, formerly with General Electric, has been appointed director of engineering at American Machine & Foundry Co.'s Rochester Division.



Minitrack equipment for station No. 1 and a VANGUARD model are inspected by (left to right): Dr. J. P. Hagen, Project VANGUARD Dir.; A. E. Abel, Gen. Mgr. Bendix Radio Div.; J. T. Mengel, Chief, Tracking and Guidance, NRL.; Capt. P. H. Horn, Dir. NRL. Vans equipped by Bendix are heading for S. American Minitrack station sites.



Naval Research Lab. scientists examining a map overlay on which the IBM 780 cathode ray tube output display will trace earth satellite's path. Left to right: Dr. J. W. Siry; Dr. Paul Herget; H. Chrisman; J. J. Fleming. Herget is in charge of computation at VANGUARD Computing Center installed by IBM in Washington, D. C.



Above, Robert Edwards, newly appointed Bus. Mgr., Cook Research Lab., Cook Electric Co. Below is D. A. Bair, Mgr., Reliability Test Section, Cook's Inland Testing Lab., a multi-million facility to include world's largest (100,000 curies) gamma radiation source.



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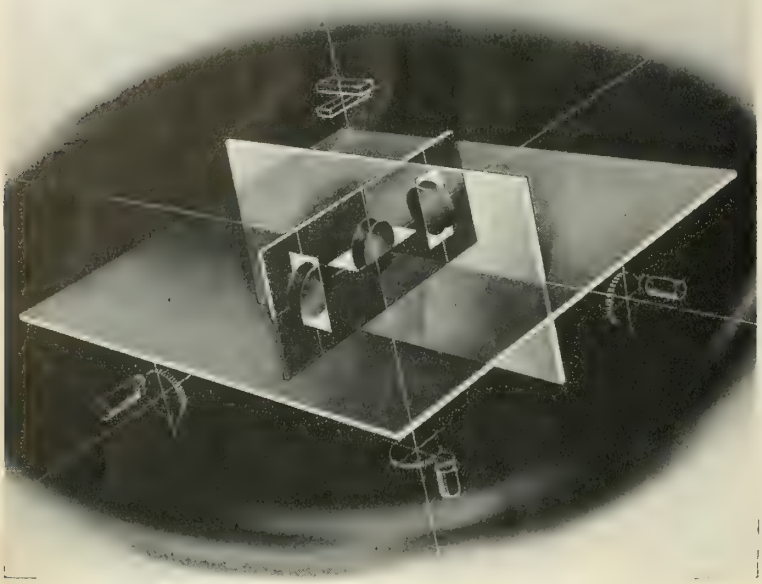
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people

Adm. John H. Sides, deputy to the special asst. to the Secretary of Defense for guided missiles, will assume the rank of vice admiral and report as director, weapons system evaluation group, Department of Defense, on August 1.

Edward C. Wagner has been appointed to the post of assistant to the vice president for engineering, Ford Instrument Co., Division of Sperry Rand Corp.

Max Moore has been appointed chief engineer for the Precision Potentiometer Division of General Controls Co.

E. Douglas Reddan and Norman C. Anderson have been elected president and vice president respectively of Infrared Industies, Inc.

George S. Schairer has been appointed director of research for Boeing Airplane Company. He was formerly chief engineer of the Seattle division.

Jack E. Shuck, formerly a colonel in the Air Force's Air Materiel command, has been appointed a staff scientist on the Product Planning Staff of Lockheed Missile Systems Div.

Charles L. Backus, Jr., has been appointed manager of the Dayton office of Autonetics, a division of North American Aviation, Inc.

S. G. Gregory has been named for the newly created position of director of personnel services for Borg-Warner Corp.

Willis M. Hawkins, asst. gen. mgr. of Lockheed's Missile Systems Div., has been appointed a member of the U.S. Army Scientific Advisory panel.

Dr. Jacob L. Zar, the Guided Missiles Div. of Republic Aviation Corp., has been appointed director of engineering by Airborne Accessories Corp.

Robert J. Mill has been named manufacturing mgr. of Aerojet-General Corp.'s Liquid Rocket Plant at Sacramento. **Y. C. Lee** has been appointed director of research and planning for Aerojet's Liquid Engine Div.

Convair Division of General Dynamics Corp. has announced the following new assignments: **William C. Dietz,** chief of B-58 project; **Norm H. Simpson,** senior project engineer; **Don R. Kirk,** senior project engineer; **Robert W. Moller,** asst. mgr. of B-58 flight test program; **J. F. Robinson,** chief of engineering test laboratories; **R. P. Scott,** chief of engineering flight test; **William H. Crow** and **J. C. Thurmond,** asst. chief design engineers.

Reginald R. Kearton, formerly director of nuclear projects for Lockheed's Georgia Div., has been named director of the new sales branch of company's Missile Systems Div. at Sunnyvale.

James R. Merrill has been named mgr. of Raytheon Manufacturing Co.'s Santa Barbara (Calif.) laboratory, suceeding Harold E. Beveridge, resigned.

John E. Ranks, who served as a missile test officer at sea and as officer-in-charge of the Officers Electronic School, Treasure Island, Calif. during the Korean war, has been appointed mgr. of the Small Systems Dept.'s product engineering section at ElectroData Div. of Burroughs Corp.

Dr. John W. Bond, Jr., has been appointed chief of the physics group at Convair-San Diego.

Edward E. Slowter has been elected vice president of Battelle Memorial Institute, Columbus, O.

Rheem Manufacturing Co.'s new Aircraft Div. has announced three key ap-

pointments: **Glen S. Gipson,** western district sales mgr. with hq. at Downey, Calif.; **P. J. Raferty,** district representaitve in Chicago; **V. E. Selvig,** legal advisor.

The following management changes are announced by Olin Mathieson Chemical Corp.: **John M. Olin,** chm. of financial and operating policy committee as well as chm. of the exec. committee; **Thomas S. Nichols,** chm. of board of directors; **Stanley de J. Osborne,** president of the corporation.

Robert Lee Baddorf has been appointed chief engineer of Topp Manufacturing Co.

Wade Wolfe, Jr., has been named technical liaison mgr. in the construction engineering dept. of Olin Mathieson Chemical Corp.'s high energy fuels organization.

Richard E. Welch, vice president and treasurer of W. M. Welch Mfg. Co., Chicago, was elected president of the Scientific Apparatus Makers Assn.

Ralph Carlisle Smith, asst. director of Los Alamos Scientific Laboratory, has been appointed assistant to the president of the Nuclear Products-Erco Div., ACF Industries, Inc.

Edmund B. Parke has been named director of Production Div. at Reaction Motors, Inc.

Baboo Ram Teree has been elected vice president—engineering and manufacturing of Greer Hydraulics, Inc.

John Carter, a vice president of Corning Glass Works, has been elected president of Fairchild Camera and Instrument Corp.

J. M. Miller has been placed in charge of all design activity on equipment for the Talos missile and **E. F. Lapman,** now chief electronics engineer, has the responsibility for design for all electronic systems, Products Div., Bendix Aviation Corp.

J. E. Schaefer of Wichita has been elected vice chairman of Boeing Airplane Co.

Dr. Seymour B. Cohn has been appointed mgr. of Stanford Research Institute's Antenna Systems Laboratory.

Dr. John P. Nash has been appointed mgr. of the information processing division, Lockheed Missile Systems Div.'s research and development branch.

David E. Shonerd has been named president of Era Engineering, Inc.; **Harold D. Hutchinson,** vice president; **Mary F. Cramer,** treasurer; and **Glendon Tremaine,** secretary.

Gladyln H. Putt has been named executive assistant to L. Eugene Root, vice president and gen. mgr. of Lockheed's Missile Systems Division. Putt was formerly with RAND Corp. as executive assistant to the president.

Sterling C. Spielman is the new director of engineering at Philco Corp.'s Government and Industrial Division. He was previously director of electronic engineering.

I. J. Hammill has been appointed as executive vice president and managing director of Walter Kidde & Co. of Canada Ltd. He succeeds C. K. McLeod who becomes chairman of the board.

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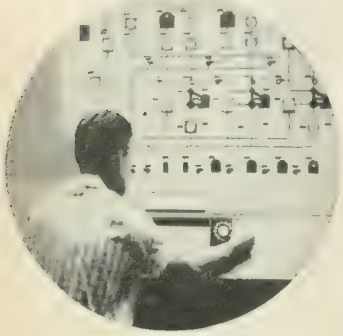
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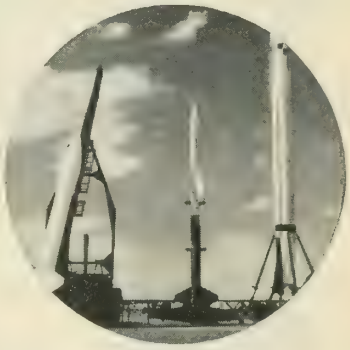
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Sperry Rand Corp. Enlarges Salt Lake Lab

Sperry Rand Corporation will add a 100,000 square foot unit to its Salt Lake City Engineering Laboratory, thus tripling the size of its Utah facility. The new unit will add 90,000 square feet of manufacturing space, 5000 square feet of environmental testing space, and 5000 square feet of utility space to the north side of Sperry's present lab.

It is reliably reported that Sperry will manufacture the Thiokol solid-propellant-powered *Sergeant* missile at the facility.

Honeywell Gets Missiles Repair Contract

New military emphasis on maintenance of missile electronic equipment has resulted in the instigation of a contract repairs program by the Aeronautical Division of Minneapolis-Honeywell Regulator Co. Named to head the new program is George P. Smith, with John S. Wagner administering the integration of production facilities and possibly reorganizing plant operations.

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Lockheed Builds New R&D Center

Lockheed's Missile Systems Division has begun construction on a new lab at its Palo Alto R&D Center, increasing the center's facilities to 218,000 square feet. The new lab is the fourth 51,000 square foot lab to be built at the Palo Alto activity. This latest addition brings the division's Bay area facilities to a total of 583,000 square feet now in use or under construction. Its Van Nuys plant, with 475,000 square feet, raises the Missile Division's total plant space to more than a million square feet.

The new lab, which will be begun at about the time the third lab in the series is occupied, is next to the last in the building program of the division's 22-acre Stanford Park industrial site. Construction will be of the concrete tilt-up type reinforced with steel.

Ryan Opens New R&D Center

Ryan Aeronautical Co. is centering all its engineering, research and development work under one roof at its new half-million dollar Engineering and Research Center in San Diego. The new center includes an environmental test laboratory, a self-contained research machine shop and the main engineering laboratory.

The new center will be used for ground testing components of high-speed aircraft and missiles. While finishing touches are being put on the two-story building, installation of special equipment is commencing. The equipment in the center includes devices to simulate extreme shock, vibration, acceleration, temperature, altitude, humidity and radio interference.

RIAS Awarded Satellite Contract

RIAS, Inc., has been awarded an earth satellite contract by the National Science Foundation, in collaboration with the Franklin Institute, to carry out measurement of the heavy cosmic ray flux. The experiment requires light-weight, shock-resistant, high performance equipment that RIAS is developing with the Martin Co.

The two companies have succeeded in developing a transistorized pre-amplifier to amplify the impulses of an ionization chamber that will detect the cosmic rays in outer space.

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Navy Opens *Vanguard* Computing Center

High-speed electronic calculations at the *Vanguard* Computing Center, which the Navy opened on July 2, will predict future orbits of U.S. scientific satellites. The center will be operated for the Navy by IBM, which will use their 704 electronic data processing system. In conjunction with the 704, which will be magnetic-tape operated, IBM plans to utilize an IBM 780 Cathode Ray Tube Display Unit. This visual display unit will picture the 704's computations in the form of graphs, geometric figures, engineering symbols or words and numbers. The display unit will actually picture a satellite's orbit.

W. R. Grace Co., Pechiney To Produce Silicon

The formation of a new U.S. company for the production of high-purity elemental silicon and other semi-conductors was announced in July by the W. R. Grace Co., of New York, and the French chemical and metallurgical firm of Pechiney. The two companies will combine their efforts in silicon production as they did in 1952 for the production of ammonia and urea in Memphis.

Cooper Development Will Enlarge Facilities

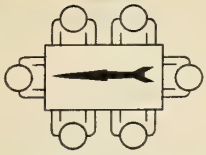
Cooper Development Corp. is doubling its plant facilities due to increased activity in the design and production of high-altitude research rocket devices, meteorological rockets, infrared equipment and special missile assemblies. The three way expansion program involves a new plant in Baldwin Park, Calif., a facility at Fontana, Calif., and a new addition at the main plant in Monrovia, Calif.

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PNEUMATIC PRESSURE REDUCER. Miniature reducer with ¼" ports conforms to MIL-R-8572A; weighs 0.17 to 0.25 lbs. depending on spring. Available with or without relief valve and adaptable to hydraulic uses. Operating temperature range from —65°F to 225°F may be altered with internal design change. Pneu-Hydro Valve Corp.
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EPOXY GLASS LAMINATES. Micaply epoxy glass laminates for printed circuitry are available in black material for uses requiring this type. Standard thicknesses include from 0.032" to 0.5". The laminates are available clad in copper or unclad. Units are also available with circuits flushed to surface of the material. Mica Corp.
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STANDARD DATA ANALYZER. Developed by Control Instrument Co., this unit simulates and projects machine operations, using precision potentiometers to control programming. Each of three dial-potentiometers represents a different factor in selecting optimum machining conditions. Control Instrument Co.
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BLAST GAGE. Microphones linear to a 200 db level vs. 0.0002 microbars for accurate reproduction of transient pressure waves without distortion are being produced which are capable of operating continuously at 160°F. Rise times on the order of 100 microseconds are measured, showing steepness of a wave front. Overall dimensions are 2⅜" x ⅝". Massa Laboratories.
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TRANSISTORIZED CONVERTER. Power conversion unit weighing 1.06 lbs. and having a conversion ratio of 85%, with only about 2% drop in ratio at 185°F. and a ground support unit with 5 DC and 3 AC outputs and weighing 3700 lbs. are both being manufactured by Wincharger Corp.
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MISSILE LITERATURE

DESIGN RELIABILITY HANDBOOK. New materials, processes, techniques, design aids and reliability concepts are treated in this handbook by the Navy Electronics Laboratory. Also deals with preferred circuits, construction techniques, design procedures, application design data, components applications notes, mechanical considerations, et al. OTS, Department of Commerce.
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DIRECT RECORDING OSCILLOGRAPHS. Illustrated bulletin describing two new models of recording oscillographs requiring no developing or processing of the record. Midwestern Instruments.
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CONVERSION FACTORS. Wall reference table for engineers and other executives that contains numerous conversions not easily located elsewhere. Precision Equipment Co.
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CRYSTAL LATTICE MODELS. Chemical element, compound, mineral and alloy models are listed and illustrated in a 6-page bulletin. Models available for advanced study. Arthur S. LaPine & Co.
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FLAME EXTINGUISHING AGENTS. Results of a survey on current knowledge of physico-chemical means of extinguishing flames. Topics discussed include methods of flame extinguishment, uninhibited and inhibited gaseous flame, actions of inhibitors and the burning of rocket-propellant chemicals. Special emphasis placed on future planning of flame-extinguishing mechanisms. Title is Survey of Fundamental Knowledge of Mechanisms of Action of Flame Extinguishing Agents. Department of Commerce.
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FUME HOODS. Closed type fume hoods for use in industrial laboratories are described in two pages of data. Accessories also described. Arthur S. LaPine & Company.
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LINEAR ACCELEROMETERS. Bulletin illustrating and describing redesigned line of linear accelerometers, including models specifically designed for recording missile launching accelerations. Overall dimension chart included with bulletin. B & F Instruments, Inc.
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TUBE BENDING. A 24 page catalog showing products available, a list of bending dies and data on minimum bending radii. American Tube Bending Company.
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MISSILE DYNAMOTOR. Data sheet o new 1500 Series units designed specifi ally for missiles use. Induction Moto Corp.
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AIRCRAFT STRUCTURAL MATERIAL Results of tests contained in two r ports, one on aluminum alloys 2024 a 7075 and another on cylindrical a tubular specimens of structural allo show causes and effects of stress, me fatigue, torsion and reduction strength. Department of Commerce.
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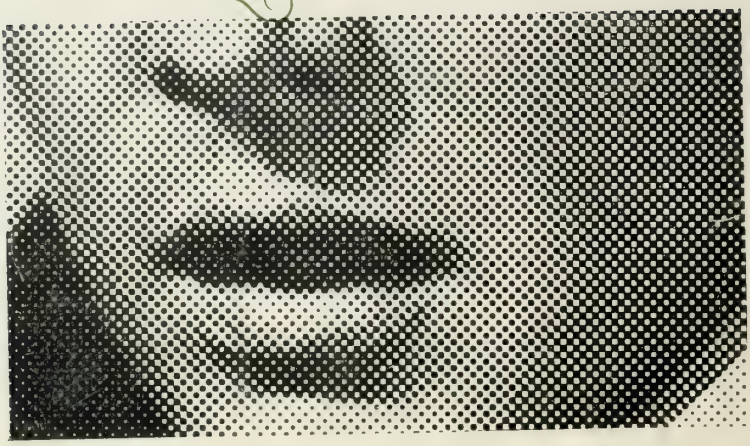
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This Issue:

LIQUID ROCKET PROPELLANTS AND EXOTIC FUELS



Friendly Foe

When a new air defense missile is produced, its "kill accuracy" is theoretical until it is tested against a realistic target under operational conditions. The new, supersonic missile target, **USAF XQ-4,** is one of many "friendly foes" developed by Radioplane to simulate various air enemy threats.

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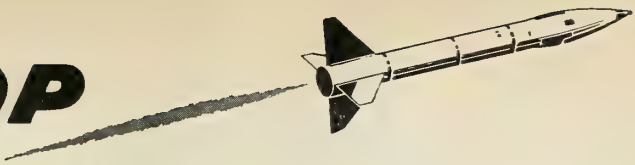
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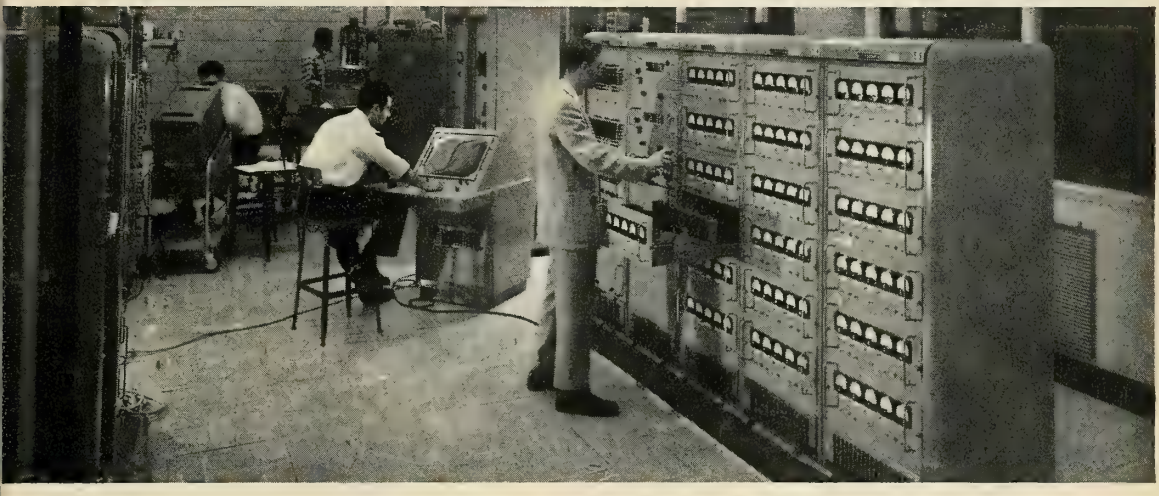
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at giant new DATA CENTER



ASCOP M Series Ground Station at General Electric's Data Reduction Center

GENERAL ELECTRIC's new multi-million dollar Missile Data Processing Center — one of the nation's largest — is now engaged in advanced scientific computation and evaluation of missile flight tests.

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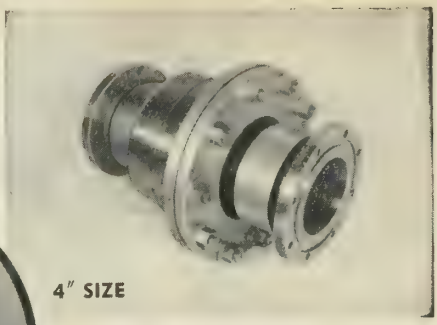
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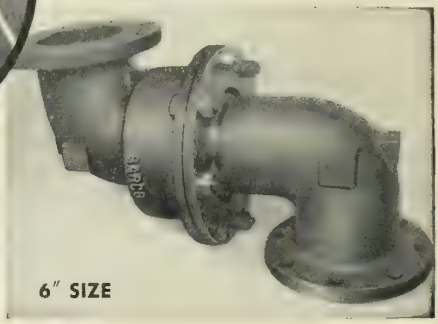


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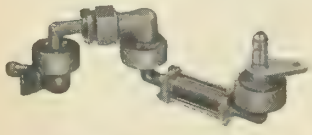
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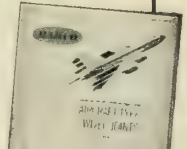
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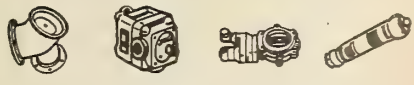
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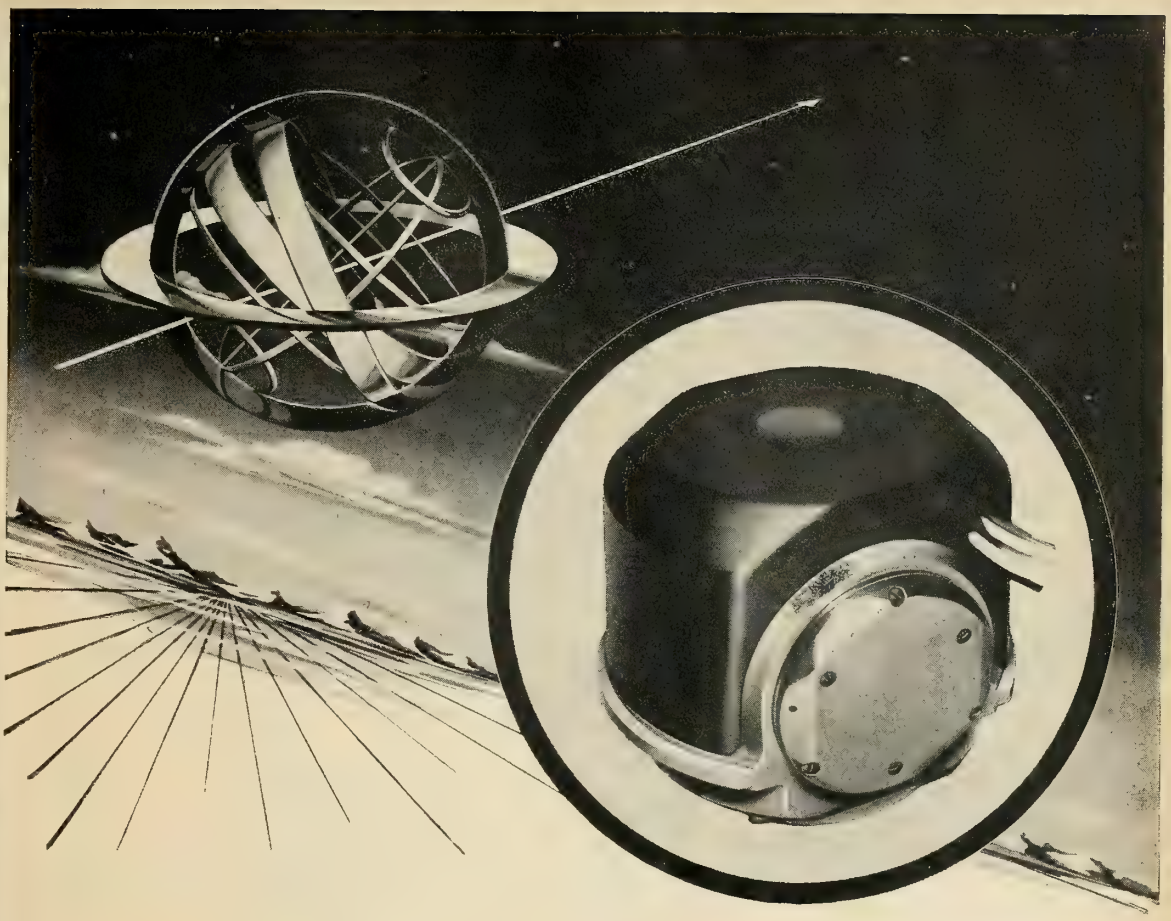
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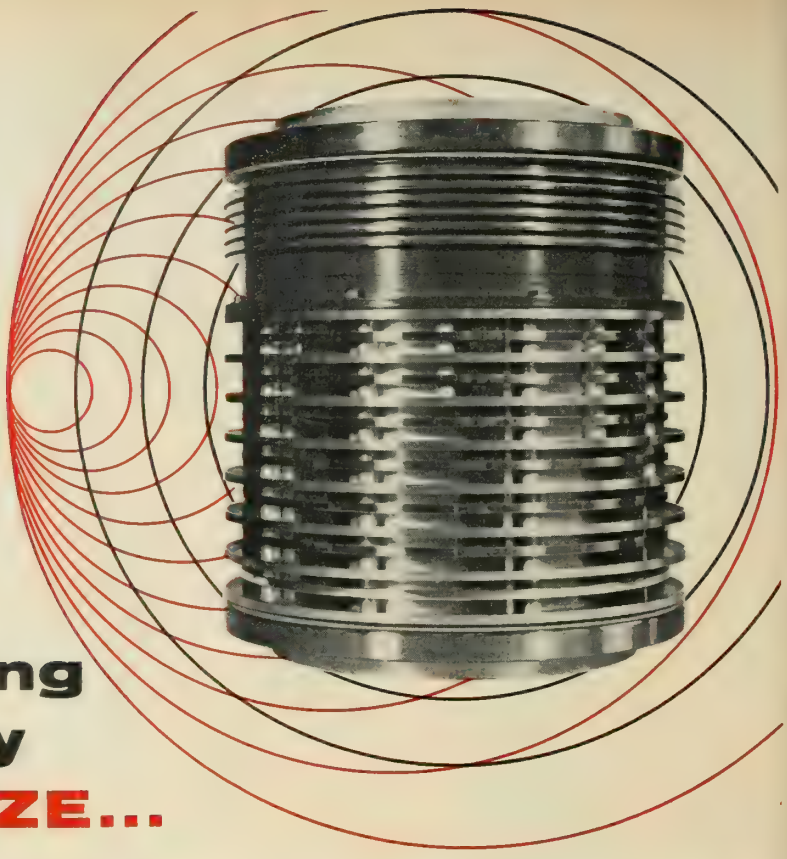
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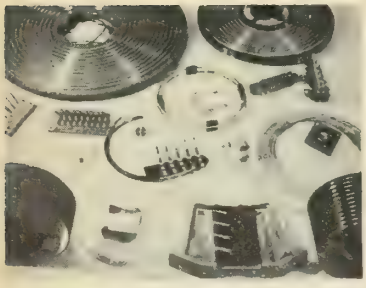
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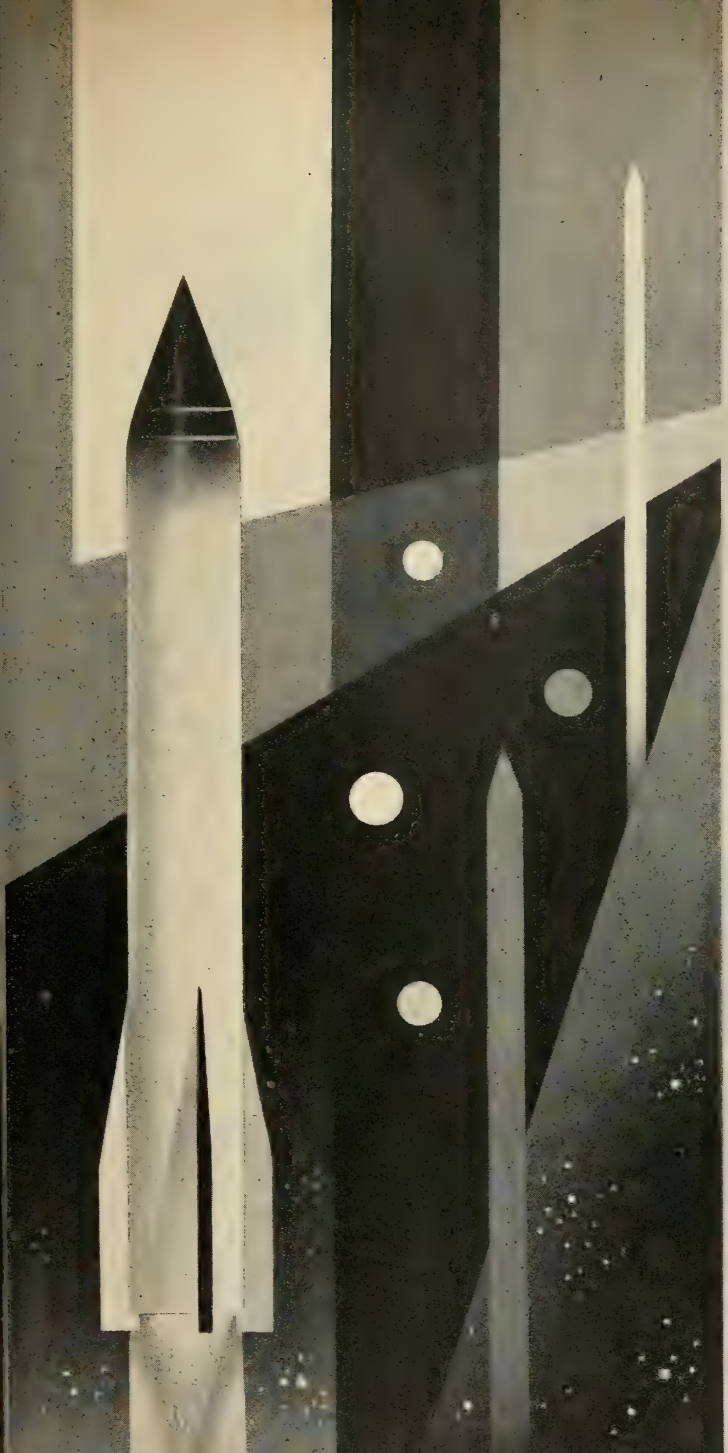
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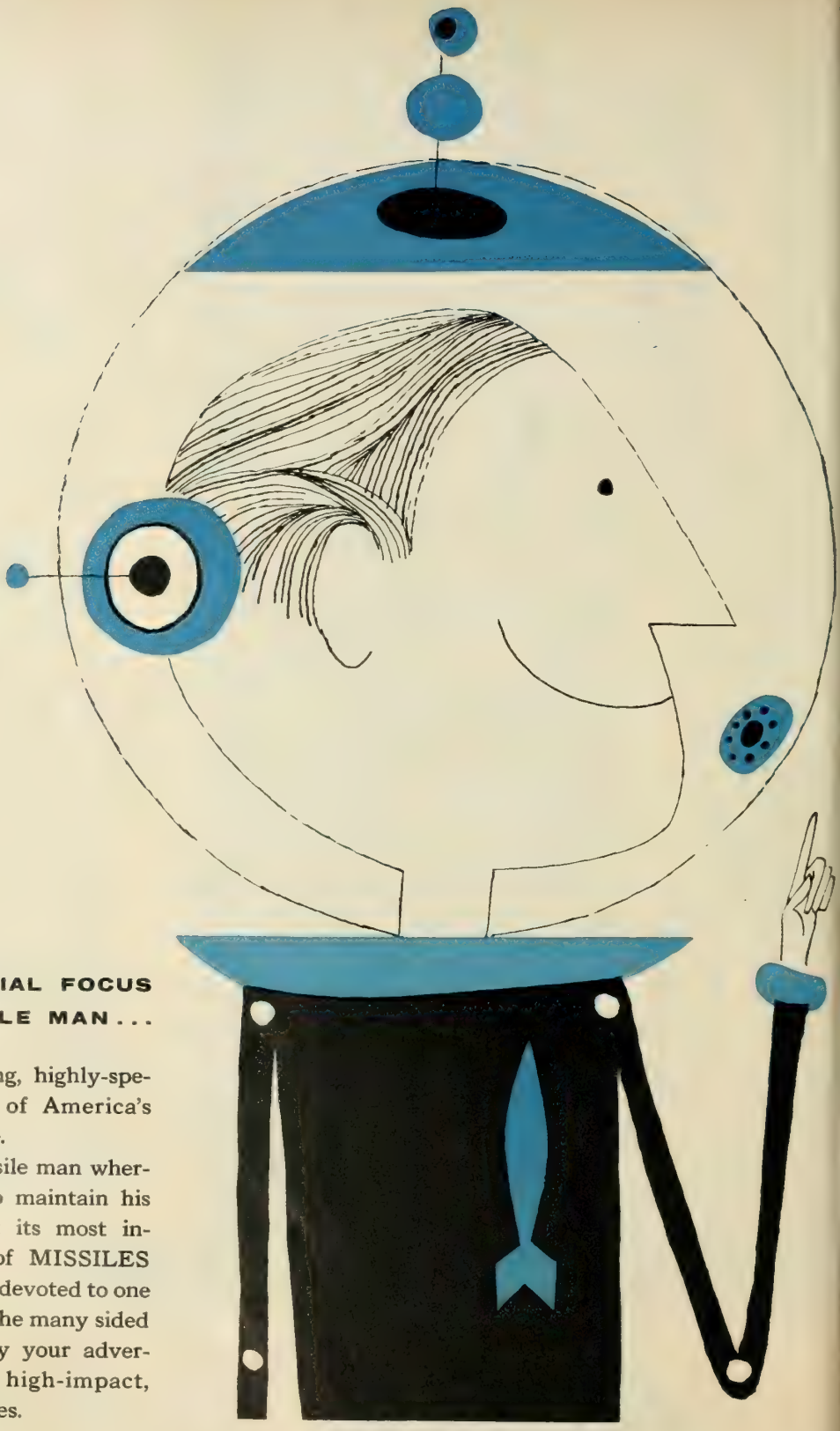
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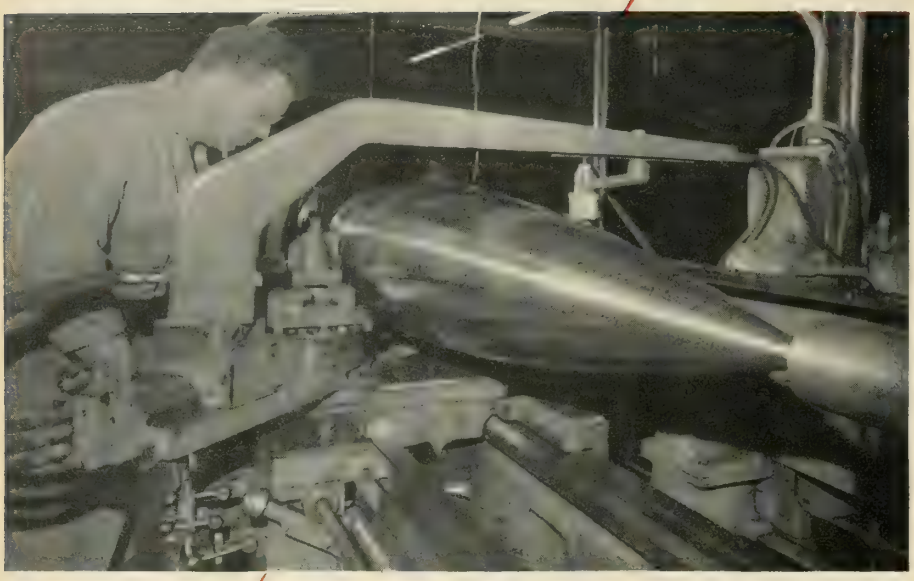
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Let's Call In General Yates!

Cutbacks in military buying and manpower are under way, with more coming. Arms cuts of major size are already in effect. Defense spending will be cut from $40.2 billion to $38 billion or less. Actually, this may be interpreted as an avalanche-type cutback, and it will be felt. The Army will feel it in terms of less manpower; the Navy must mothball 60 major combat ships; the Air Force will stretch out and cut orders for planes.

Businesswise, our missile programs will not suffer much, in spite of such drastic cancellations as the death of the *Navaho.* Those 12,000 or more people weren't all working on the *Navaho,* were they? Furthermore, North American's facilities and engineering capabilities represent such an asset to the nation's missile knowhow, that North American already is back in business. However, current defense cutbacks will mean a streamlining of the missile program. This isn't to say that there will be a cutback in terms of ultimate missile striking powers. But the White House expects more and better missiles for less money. This makes sense. We are beginning to learn.

Nevertheless, it remains a fact that the missile business is still in quite a messy state. It is rather disorganized. Very few people know very much about where we're going, nor the best way to go about getting there. That's why the White House asked for action. Reportedly, important decisions will be made next month when the policy makers sit down and discuss where we're headed, what should be cut and what should be done, in general, to eliminate wasteful spending. In other words, decisions vital to our current and future defense will be made.

In this connection, the spotlight will be on our new Secretary of Defense. Neil H. McElroy is known as a man who wants facts, not theories, from subordinates and associates. His approach probably will be much like Charlie Wilson's, viewing the job as a business rather than a political or technical problem. He is known to be digging hard for facts. He makes up his mind quickly, and only new facts can make him change a decision.

There's nothing wrong with that approach, so long as fact can be sorted from fiction. This hasn't always happened. Many people lay claim to the role, but few are missile experts. Very few. When McElroy starts digging for facts he most certainly will have to turn to some of those few who know something about missiles, those who have built and flown missiles successfully. And they are not always where you expect to find them.

To arrive at the optimum of overall missile producibility and operational effectiveness, the new defense secretary ought to call in the man who knows more about Army, Navy and Air Force missiles than anyone else . . . AF Maj. Gen. Donald N. Yates. He is Patrick AFB's energetic, eager commander. He is the only top military man who has had the opportunity—for several years—to watch all the birds all the time, who has had daily contact with the missile industry's researchers, designers and military brass—even the push-button personnel—and who has built up a truly vast scientific knowhow of our entire missile arsenal.

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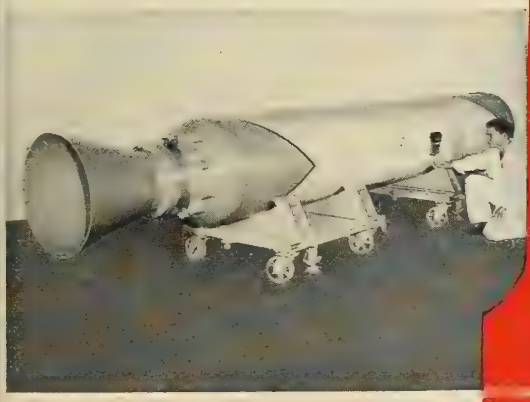
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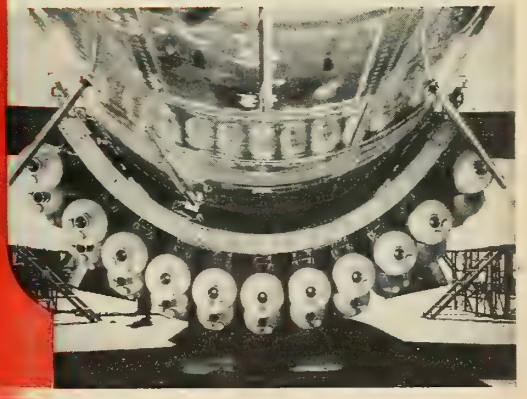
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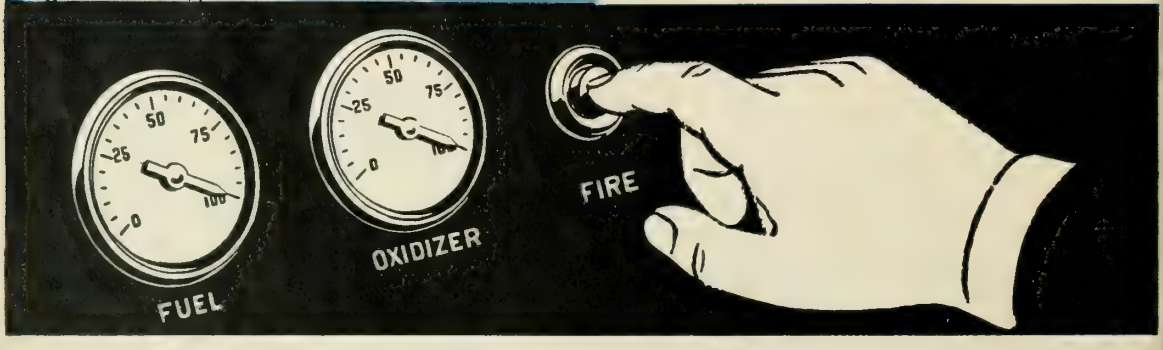
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GUIDED MISSILES AND ROCKETS AROUND THE GLOBE

cover picture:



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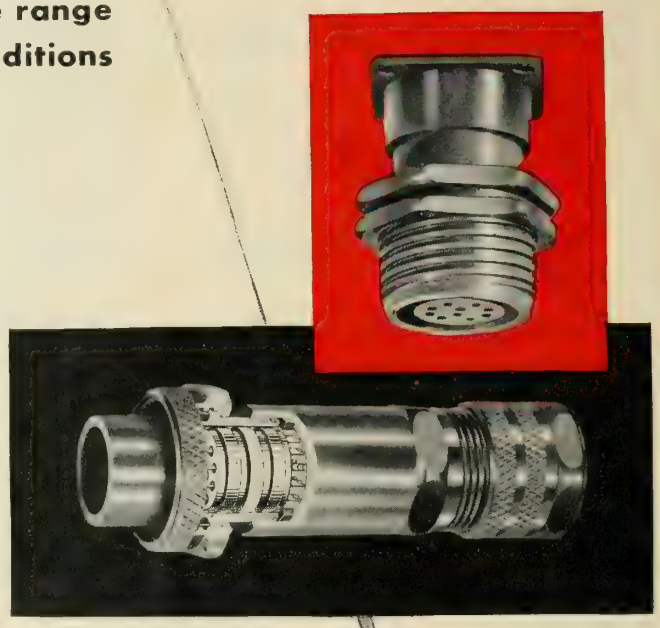
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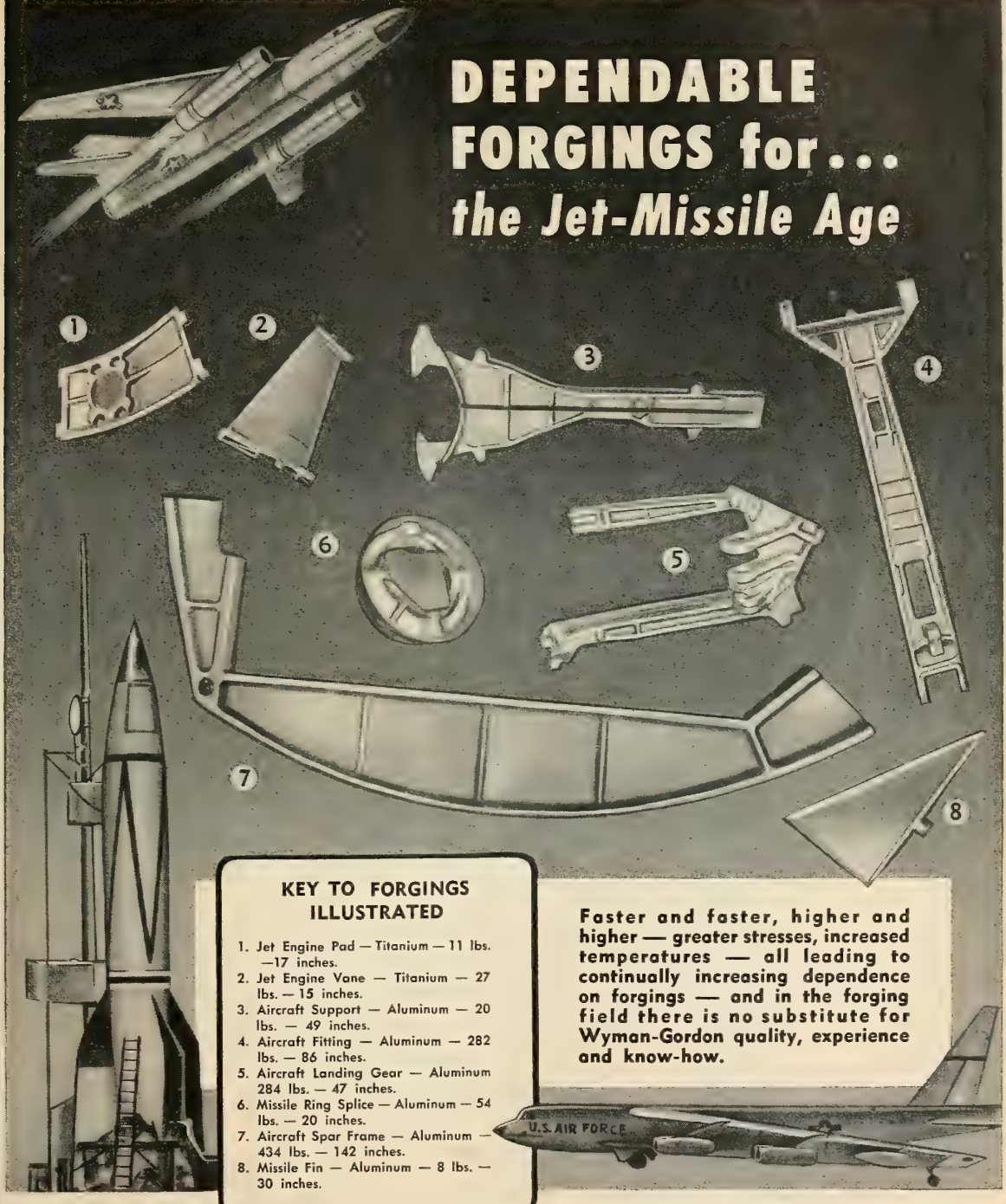
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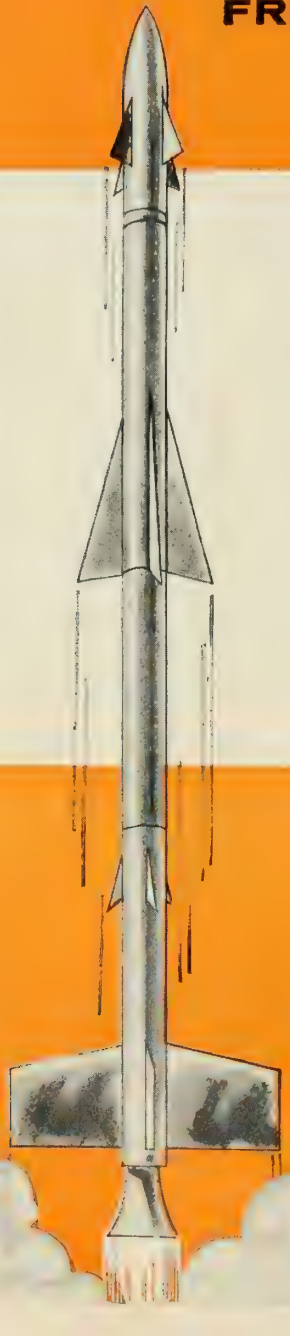
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which describes the facilities and products of the Jet Division in detail, shows how you can use these facilities to best advantage.



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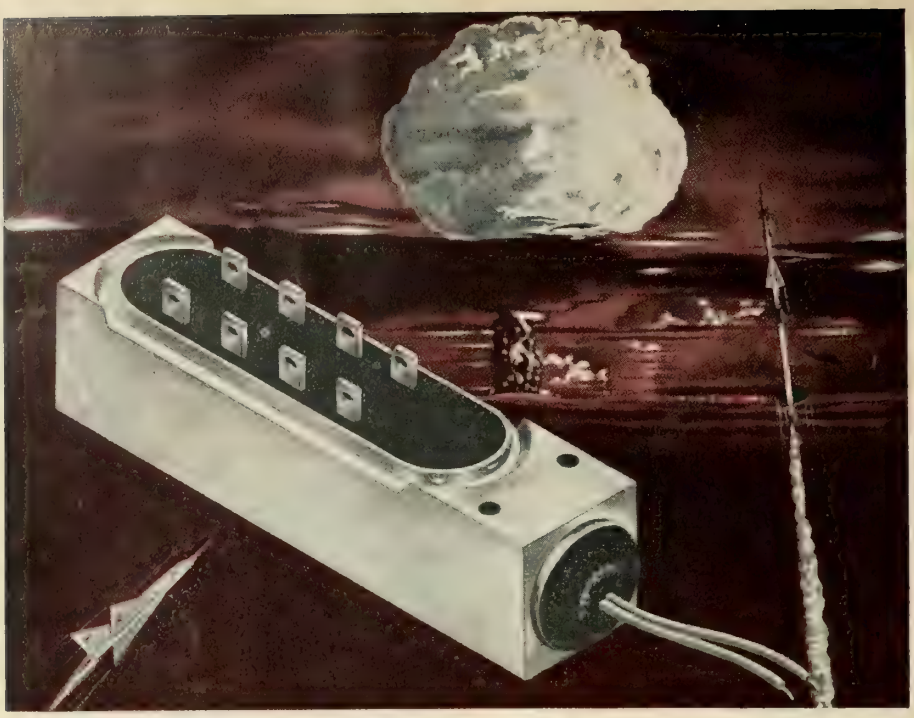


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. . . try this Rugged and Reliable, featherweight squib-actuated switch

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- Size: ½" x ½" x 2⅛" (Terminals extend ⅛") (Non-delay)
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  *Actuation Times as short as 0.1 millisecond and as long as 20 seconds will be available.

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letters

Solid-fuel Issue is Challenge

To the Editor:

Your magazine serves extremely useful purposes. Not only does it keep the layman up to date on a common sense basis but it also provides information in well co-ordinated comprehensive form a businessman can understand.

But most important of all, the statements in your magazine must be appreciated for their authoritative value at a time when advertising writers and customers' men in brokerage offices have suddenly become experts on missiles, rockets and jets and, with the help of a few chemical terms, dispense so glibly an appalling amount of hogwash that at best represents 25 per cent half-baked knowledge, 25 per cent imagination and 50 per cent stupidity.

Your article on the solid fuel industry is excellent in every respect and I am looking forward with much pleasure to your next issue which will discuss the exotic fuels and their values, about which there is so much controversy.

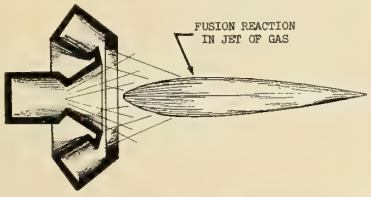
A. Swoboda
Securities Cycle Research Corp.
60 East 42nd St.
New York 17, N. Y.

A New Road To Controlled Fusion?

To the Editor:

Here is an idea I thought of three years ago. I have tried to make it several times, but haven't succeeded yet.

The rocket works on the "hollow charge" principle.



I thought that this engine would increase the rocket exhaust velocity and could be throttled. The directional control is similar to the air nozzle in the Ator VTOL. Most important about this is that you might be able to have a nuclear fusion reaction in the jet of the rocket.

This could be done by having a plasma jet of tritium and deuterium focused so that the molecules collide similar to a "hollow charge" which would form tremendous heat to start the fusion reaction.

The heat problem would be solved because the fusion reaction is away from the walls of the rocket chamber.

Russell H. Jones, Jr.
112 N. Abington St.
Arlington, Va.

To the Editor:

Our Society, the Asociacion Argentina Interplanetaria, is a member of the International Astronautical Federation and has nearly 500 members of which about 30% are university graduates, 35% are university students and the rest are amateurs. We are organizing a big exposition to be held in Buenos Aires, December 1957-February 1958 and expect to get some material to be exhibited from foreign countries. We will also exhibit some small rocket motors built in this country and some models of different satellites as well as designs, graphs and photographs of rockets.

We ask you to consider the possibility of sending us on a loan basis some of the material you have exhibited at the Sheraton Park exhibition hall. We are sure you have many, very interesting things to be exhibited in this great Latin American city.

Teofilo M. Tabanera, President,
Asociacion Argentina
Interplanetaria
Buenos Aires
Argentina

We feel the best sources for you to contact would be the American Rocket Society, 500 Fifth Avenue, New York, N. Y., and the State Department, Argentine Desk, Washington 25, D.C.—Ed.

SRO at m/r

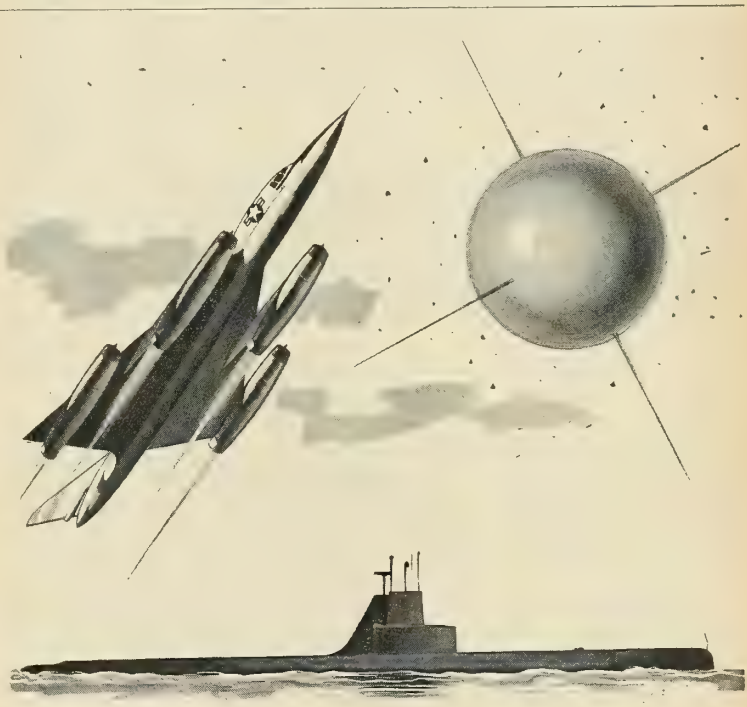
To the Editor:

I have just received a two year subscription to your magazine and would just like to say the first copy exceeded my expectations. Keep up the good work.

I would like to know if the back issues of m/r are available. My subscription started with the July, 1957 issue.

Gene A. Lewis
15718 Mandalay Rd.
Cleveland 10, Ohio

Sorry. No back issues available. All gone.—Ed.



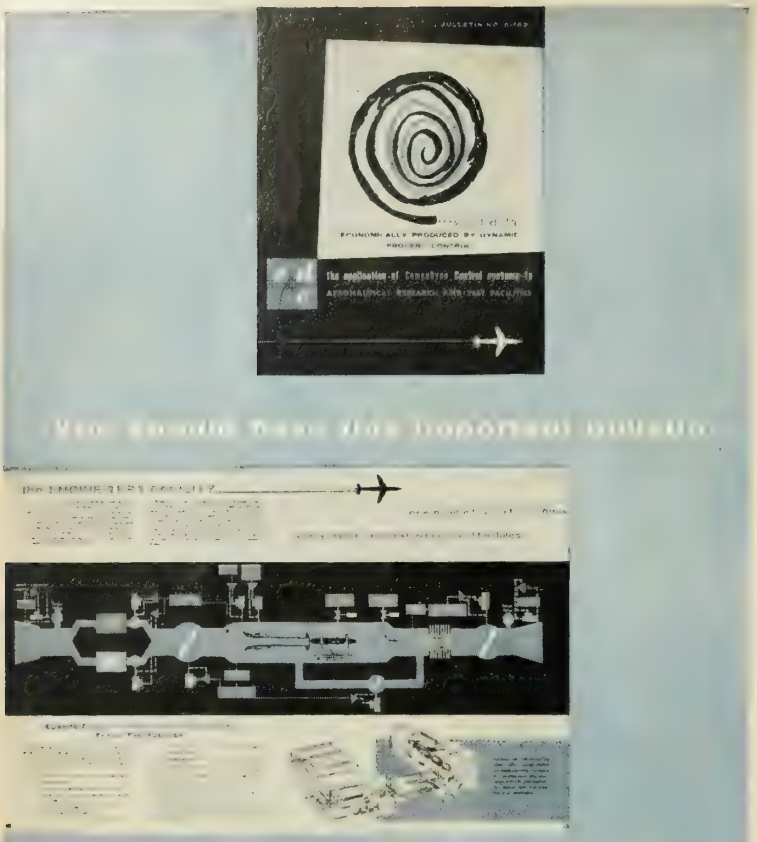
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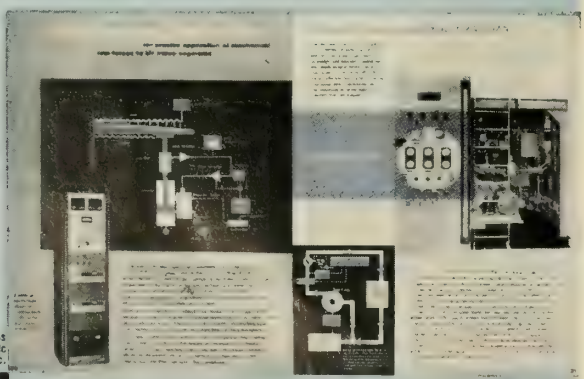


If your company operates any form of aircraft or component test facility, you should have this new bulletin. It's yours . . . without obligation.

Entitled "VALID DATA, economically produced," this bulletin contains information that has never before been published. Here are new facts on the economics and applications of dynamic control to test facilities. This bulletin can give you insight into an entirely new kind of thinking.

The information provided shows practical means to increase the validity, output and dimension of test data.

Write, wire or telephone for your copy of Bulletin G-102.



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Our Ed Gets New Look

To the Editor:

I am an engineering student and enjoy your excellent magazine very much.

A group of my classmates and myself were discussing MISSILES AND ROCKETS the other day. We agreed that one of the best things about it is the column, Missile Business (formerly Aerophysics), written by Seabrook Hull. He is an extremely colorful writer. However, we



Ed Hull: New Look



Ed Hull: Old Look

were curious about what he was thinking when his picture, which appears at the top of the column, was snapped. We made the following conjectures:

1) His wife had just run off with another man.
2) She came back.
3) He had just given up smoking.
4) You are not paying him what he thinks he's worth.
5) He had just been told by his doctor he has to give up drinking.
6) He had been drinking too much the night before.
7) He lost $200 on a horse.
8) Aviation Week scooped him.
9) The photographer reminded him of his father whom he hates.
10) He hates everybody.

Tom Monahan

369 Bleeker Street
New York City, New York

Thanks for those kind words on Seabrook (Ed) Hull's column. He's not quite as mean as he looks. However, Ed is such a busy man around here, we never got around to having his picture taken, so an old passport photo was used over the column. But your letter did it.—Ed.

Future Lady Missileer Wants Advice

To the Editor:

I am a junior in high school and am very interested in astronomy, missiles and rockets. I make A's in school and am taking physics, chemistry, and algebra as well as other required subjects. I think I would like to major in physics, since I am more interested in rockets and missiles and actually going into outer space than I am in just studying the stars. Could you tell me what subjects I will need, how to select a college for this, and any other information I might need?

Miss Marsha Meador

625 9th St. N.
Columbus, Miss.

There are three basic subjects that should be included in your high school curriculum—Chemistry, physics and mathematics. There are many excellent colleges throughout the country that can supply the required courses. We suggest you contact your high school counselor for individual guidance. If you are 18 years of age you can and should join

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the American Rocket Society as a student member. Good luck!—Ed.

m/r Encyclopedia for National War College

To the Editor:

The National War College has selected the following item, among others, as required reading during a five-week course beginning Oct. 11, 1957:

First Annual Guided Missile Encyclopedia, MISSILES AND ROCKETS, July 1957.

Your advice is solicited with regard to securing a minimum of 160 copies for distribution to the students and faculty.

F. E. Fitzgerald
Faculty Service Consultant
The National War College
Washington 25, D. C.

Reprints are in the mail.—Ed.

A Question of Semantics

To the Editor:

There has been a rapid evolution in the aviation industry which has affected many fields. The latest to be affected appears to be semantics. Several times recently I have seen the word "sophisticated" used in aviation literature with a new meaning quite at variance with its original meaning. The latest such usage that I have noted was in your June editorial: "This Is Not the Time to Cut," where you refer to the "more *sophisticated Titan.*" Would you please enlighten me as to your definition of this ubiquitous adjective, and the authority for such a definition.

R. B. Wall
6401 Lander Lane
Dayton, Ohio

Webster's states that one of the definitions of sophisticated is "deprived of original simplicity, made artificial, or, more narrowly, highly complicated, refined, subtilized, etc." Use of the word "sophisticated" in reference to the Titan was simply to say that the Titan is considered to be more advanced and a more complex missile, which is in accordance with Webster's definition. Who started using the word "sophisticated" in aviation and missile circles isn't known, but usage has spread.—Ed.

Not That Young

To the Editor:

The fifth paragraph in the July Astrionics column is resented. Please be informed that the average age of most licensed, transmitting radio amateurs is approximately 30 years. This makes your reference to "high school kids and other amateur hams" misleading to the reader. I have enjoyed amateur radio as a hobby since 1915 and have been licensed by our federal government since 1927. My resentment comes only from unfavorable publicity the radio amateurs unjustifiably receive. Let's hear more of the many favorable things.

F. C. South W3AIR
Electronics Engr.
APL/JHU

We seriously respect the fine traditions of amateur radio operators and are sorry if Mr. South mistook our intentions. However, there are always some irresponsible persons in every field. It is because of this that the audio tones to be used are secret.—Ed.



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Here G. D. Schott (right), Flight Controls Department head, discusses computer solutions of control and guidance problems with E. V. Stearns (center), Inertial Guidance Department head, and J. E. Sherman, Analog Computer Section head.

Lockheed Missile Systems announces new positions in

MISSILE FLIGHT CONTROLS — *the creative field for engineers*

Few fields equal missile systems flight controls in the need for original thinking. The ever-increasing performance of missiles presents problems that grow constantly in complexity. At Lockheed, weapon systems programs demand important advances in flight controls. Emphasis is on new ideas, new techniques.

Positions are open on the Sunnyvale, Palo Alto and Van Nuys staffs for engineers possessing strong ability and interest in: Research and development of advanced flight control systems for controlling missiles and rockets; system synthesis by application of control system feedback techniques; analysis and design of nonlinear servo systems; development of transistor and magnetic amplifier techniques in the design of advanced flight control systems; analysis and simulation of the dynamic performance of the guidance – autopilot – airframe combination; development of systems utilizing advanced types of inertial and gyroscopic instruments; analysis and design of hydraulic servo systems for controlling missiles at high Mach numbers; environmental and functional testing of prototype flight control systems.

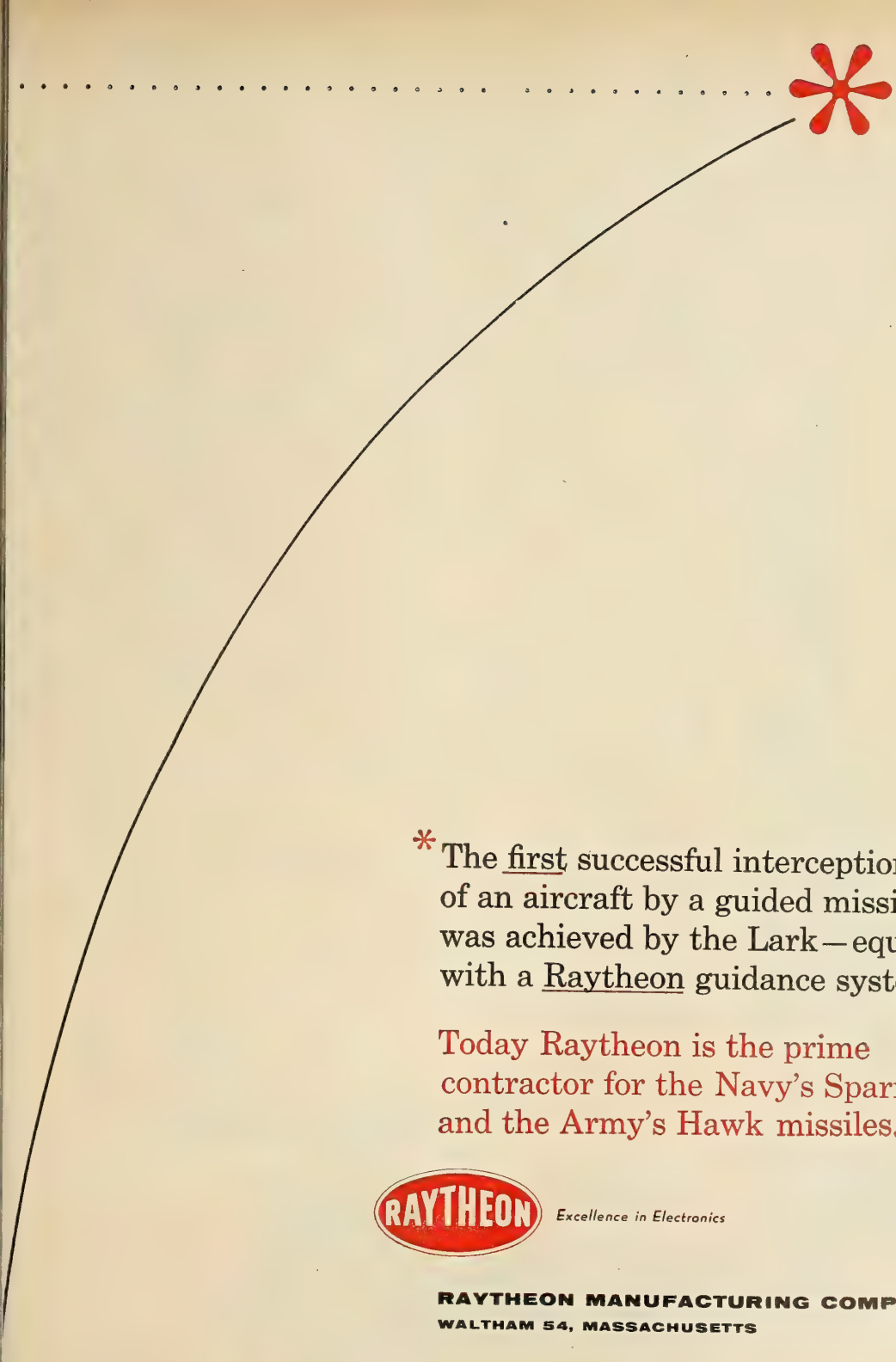
Inquiries are invited from engineers possessing a high order of ability. Address the Research and Development Staff, Palo Alto 7, California.



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Today Raytheon is the prime contractor for the Navy's Sparrow III and the Army's Hawk missiles.

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SIXTY SECONDS TO CATCH A SUNFLARE

IGY leads off with an assist from CDC

Sunflares leap into space at velocities which stagger the imagination. They occur without warning and last but a few minutes. To get vital sunflare information when it's available CDC rocket crews get the two-stage research rocket off in sixty seconds! Then, from an 80 to 150-mile-high vantage point, instruments in the NIKE-DEACON or NIKE-ASP combination detect and telemeter data on the sun's radiation—important new information to expand our knowledge of radio propagation.

CDC was awarded the IGY Sunflare contract by the Naval Research Laboratory, and was responsible for modifying and assembling the two-stage rocket vehicle, and building the instrumentation-telemetering head. Here is another important activity where CDC skills are helping speed the answers to questions in high-altitude research.

COOPER DEVELOPMENT CORP.

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Designers and builders of the ASP—the world's fastest single-stage solid propellant rocket.

Scientists and creative engineers . . . investigate this field with a future. Challenging working environment in Southern California.



when and where

SEPTEMBER

Society of British Aircraft Constructors, Ltd., 18th Flying exhibition Royal Aircraft Establishment, Farnborough, Hampshire, England, Sept. 2-8.

International Union of Geodesy and Geophysics. General Assembly, (IUGG), Toronto, Sept. 3-14.

American Physical Society Mtg., Boulder, Colo., Sept. 5-7.

American Chemical Society Mtg., Hotels Commodore, Statler, Park Sheraton, New York, N. Y., Sept. 8-13.

Second Annual Course on Investment Castings, Massachusetts Institute of Technology Cambridge, Mass., Sept. 8-13.

Twelfth Annual Instrument-Automation Conference & Exhibit, Cleveland Auditorium, Cleveland, Ohio, Sept. 9-13.

Damage Criteria for Shock and Vibration Conference, Cambridge, Mass., sponsors: AFOSR/SRD (HOST) Interservice Technical Committee on Shock & Vibration, Sept. 12-13.

OCTOBER

National Electronics Conference and forum on electrical research, development and application, Chicago, Ill., Oct. 7-9.

NACA Lewis Propulsion Lab. Triennial Inspection, Cleveland, Ohio., Oct. 7-9.

International Astronautical Federation, 8th Annual Congress, Barcelona, Spain. Oct. 7-12.

ARDO Fifth Annual Science Symposium, Interdepartmental Auditorium (across street from AFOSR hqs). Host Center: AFOSR, Washington, D. C., Oct. 8-9.

Society for Experimental Stress Analysis Nat'l Fall Convention, El Cortez Hotel, San Diego, Calif., Oct. 9-11.

Canadia Institute of Radio Engineers Convention-Exposition, Automotive Bldg., Exhibition Park, Toronto, Canada. Oct. 16-18.

ASME Conference on New Developments in the Field of Power, Americus Hotel, Allentown, Pa., Oct. 21-23.

Aeronautical and Navigational Electronics 4th Annual East Coast Conf., sponsored by Baltimore Section, IRE and the Professional Group on Aeronautical and Navigational Electronics, Fifth Regiment Armory, Baltimore, Md., Oct. 28-30.

Association of the U.S. Army Third Annual Mtg., Sheraton-Park Hotel, Washington, D. C., Oct. 28-30.

American Nuclear Society, Henry Hudson Hotel, N. Y., Oct. 28-31.

NOVEMBER

Military-Industry Guided Missile Reliability Symposium, Naval Air Missile Test Center, Pt. Mgu, Calif., Nov. 5-7.

Third Aeronautical-Communications Symposium, Utica, New York, sponsored by IRE-PGCS, Nov. 6-8.

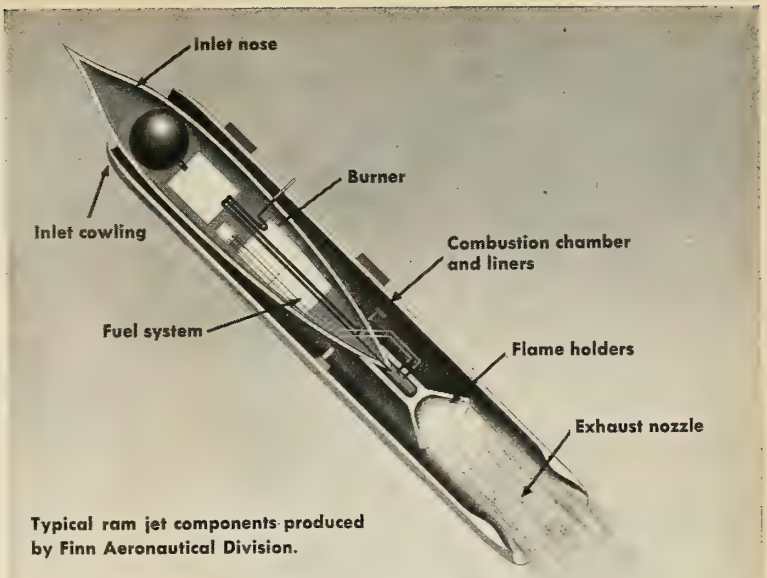
IAS Weapons System Management Mtg., Statler-Hilton Hotel, Dallas, Tex., Nov. 7-8.

DECEMBER

ASME, Annual Mtg., Hotel Statler, New York, N. Y., Dec. 1-6.

American Rocket Society Annual Mtg., Hotel Statler, New York City, Dec. 2-6.

ARS 1957 Eastern Regional Student Conf., sponsored by the Polytechnic Institute of Brooklyn Chapter, Hotel Statler, New York, Dec. 6-7.



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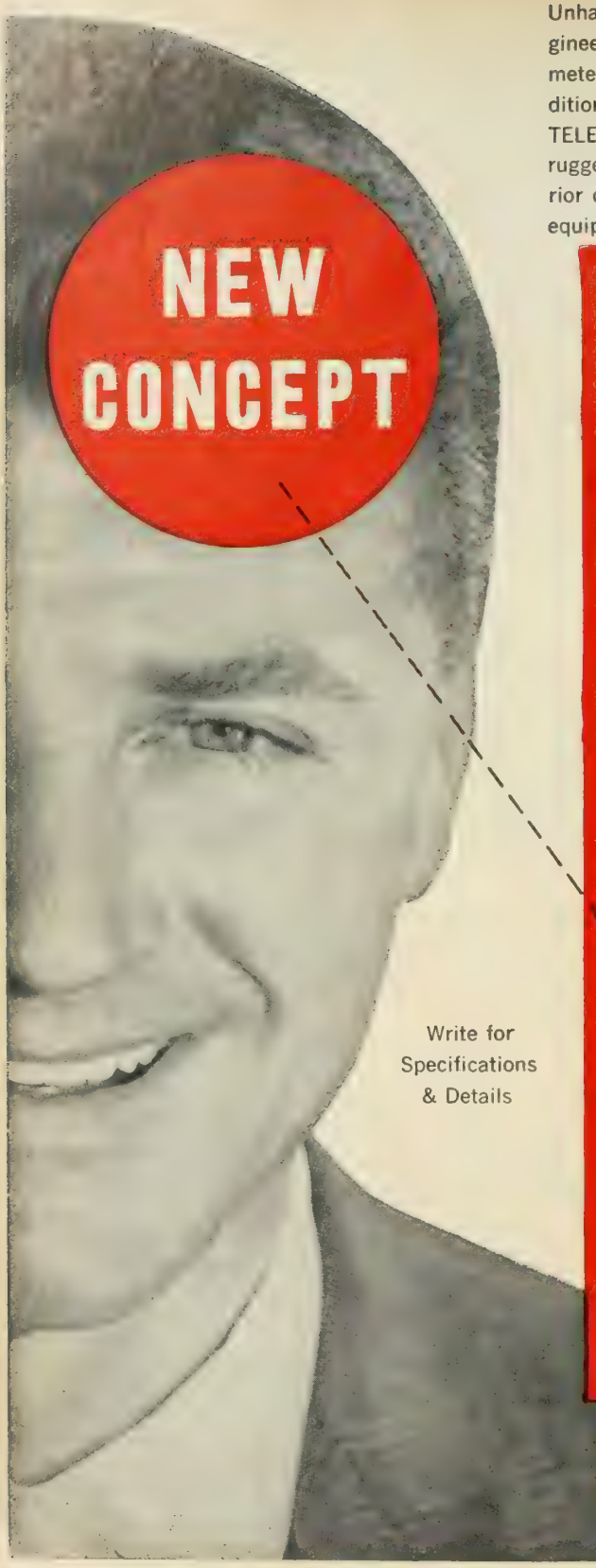
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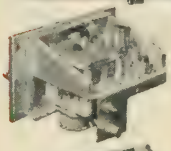
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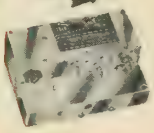
Direct FM Transmitters Crystal controlled 215-235 megacycles. 125kc deviation.



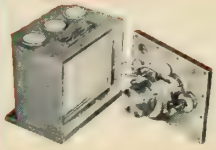
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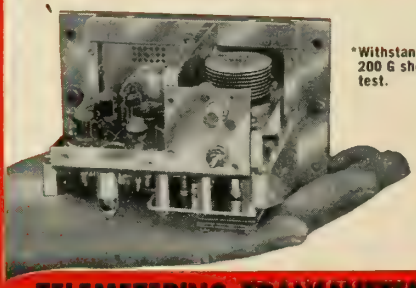


Model 1460—5" x $4\frac{5}{16}$" x $3\frac{15}{16}$"
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*Withstands 200 G shock test.

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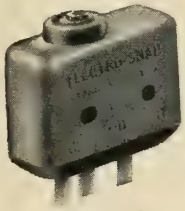
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Subminiature sealed switch is environment-free; mounts interchangeably with MS25085



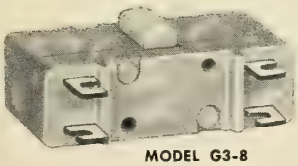
MODEL EF-3

gle Pole, Double Throw
ve. Differential, .004 Max.
ertravel, .003 Min.
er. Force, 5 to 17 oz.
ease Force, 60 gram
c. Life Ratings:
150,000 ops. @ 125/250 V. A.C.,
2.5 AMP.
100,000 ops. @ 125/250 V. A.C.,
5.0 AMP.
50,000 ops. @ 30 V. D.C.,
(2.5 AMP., IND.; 4.0 AMP., RES.)
ib. Temp., −65° to +180° F.

Sealed in a corrosion-resistant, treated aluminum enclosure, this tiny switch is environment-free; highly vibration and shock resistant. It carries 5 amps. at 125/250 V.A.C. with an electrical life rating of 100,000 operations. Low operating force and small movement differential make it ideal for bi-metal temperature, diaphragm operated and other "feather-touch" devices, while small size permits mounting singly or ganged in restricted space. Rugged and dependable, it has positive snap action.

iny 40 amp. basic switch has high ipacity, longer life and constant ability of tolerances

easuring only 1¾" x 43/64" 15/64", the Electro-Snap G3-8 sic Switch handles current rat-s up to 40 amps. A new thod of combining Electro-ap's double-break action with heavy-duty switching element ures electrical and mechanical of 100,000 cycles at large



MODEL G3-8

pacities; also provides constant stability of tolerances and accurate eatability. New plastic compound case gives the switch an am-nt temperature rating of —100° to +300° F. with extreme shock istance. Small size makes it ideal for motor controls and compact omation set-ups. A wide range of actuators is available.

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40 AMPS @ 125/250 V. A.C.
@ 30 V. D.C. Res.

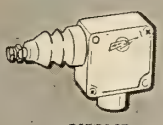
Oper. Force, 45 oz. Approx.
Overtravel, .015" Min.
Move. Differ., .055 ± .010

ELECTRO SNAP

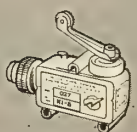
PRECISION SWITCHES



BASIC SWITCHES



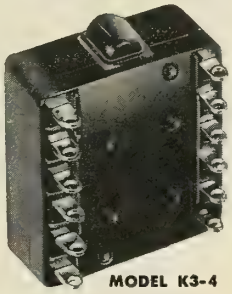
DIECAST ENCLOSED SWITCHES



HERMETICALLY SEALED LIMIT SWITCHES

CONFORM TO MIL & AN SPECIFICATIONS

Simultaneous triple-pole switch interrupts 3-phase ac. circuits; 6-circuit control in a small package



MODEL K3-4

Triple-Pole, Double Throw
15 AMP., 125/250 V. A.C.
30 V., D.C. Res.
10 AMP., 30 V., D.C., Ind.
Overtravel, .015 Min.
Move. Diff., .028 ± .007
Mech. Life, 1,000,000 ops.
Elec. Life, 500,000 ops.

This Electro-Snap triple-pole switch simultaneously reverses current flow through three windings of a 3-phase motor up to 1 H.P. and interrupts other types of multi-switching installations. Instantaneous "make" and "break" snap-action of the three poles is independent of the speed of actuation—even extremely slow moving cams can be used.

The K3-4 Series offers designers a wide variety of 3-phase circuit hookups for servo-controls, to limit movement of machine members and as a start-and-stop switch which formerly were possible only with complicated relays or a number of separate switches. A large selection of standard actuators is available.

Small basic switch is low cost; directly interchangeable with AN3234 Specs



F2 SERIES

These Electro-Snap F2 Series snap action switches are extra-compact with extremely high electrical capacity for their size. Mechanical and electrical life at 1/32" overtravel is 150,000 operations, minimum, with accurate repeatability and constant stability of tolerances. Self-aligning springs provide contact wiping action rare in a switch of this size.

Durable case of special plastic gives the switch an ambient temperature rating of −100° to +275° F. or +375° F. Available, *at low cost*, in three basic models with a wide selection of actuators.

SERIES F2 BASIC SWITCH: F2-3: Single Pole, Double Throw
F2-2: Single Pole, Normally Open; F2-1: Single Pole, Normally Closed

OPERATING CHARACTERISTICS

Electrical Rating: 10 AMP. 125/250 V. A.C. 60 cycles
30 V. D.C. inductive and resistive (6 AMP, 30 V. D.C. for Airborne Application)
Operating Force, 7 to 12 oz.
Reset Force, 4 oz. Min.
Pretravel, 3/64 Max.
Movement Differential, .011 ± .005
Overtravel, 1/32 Min.

SEND COUPON FOR MORE DATA

ELECTRO-SNAP SWITCH & MFG. COMPANY
4252 W. Lake St., Chicago 24, Ill.

Please send data sheets on switch checked:

- ☐ EF-3 — subminiature sealed
- ☐ G3 — 40 Amp. basic
- ☐ K3 — Triple-pole
- ☐ F2 — Extra-small basic

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COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

MOTIONS-IN-MINIATURE
CLUTCHES BY FORMSPRAG



ACTUAL SIZE

Now! The modern sprag principle comes to small over-running clutches

Formsprag—pioneer in the development of sprag-type clutches—now offers a truly versatile small clutch for a wide variety of aircraft applications.

In terms of your product's performance, Formsprag FS-02 and FS-04 Clutches provide unusual compactness, utmost accuracy and torque, simple and dependable operation.

Shown is a standard model. However, inner and outer races can be machined to provide through shafts, external gears, etc. Carefully controlled aviation quality and approved inspection procedures insure outstanding precision.

HERE'S REAL COMPACTNESS

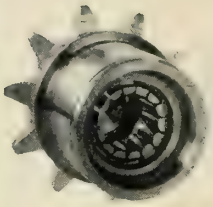
	Bore Size	O.D.	Torque	Over-running Speed
Model FS-02	¼"	1¼"	50 in. lbs.	*2400
Model FS-04	⅜" and ½"	1⅝"	200 in. lbs.	*2400

*Higher speeds possible on special applications. Consult with factory.

CHECK THESE TYPICAL AIRCRAFT CLUTCH EXAMPLES

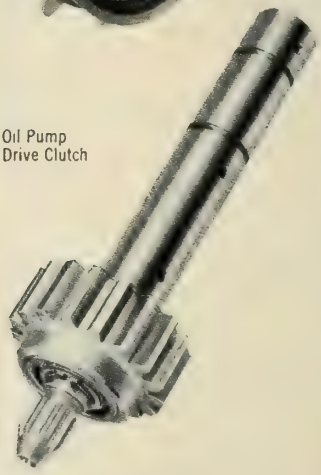


Backstop Clutch for Ammunition Feeders



Gas Turbine Starter Clutch

Oil Pump Drive Clutch



Among other uses are backstop clutches on positioning devices for electronic tubes and automatic uncoupling for energy dissipation on radar antennae drives. The FS-02 and FS-04 series can be custom manufactured in a variety of materials including stainless steel or supplied in any specified rust inhibiting process.



MORE INFORMATION?

Should you require details on these Formsprag small clutches as well as the complete line, write today for this new 26-page catalog.

Over-Running, Indexing and Backstopping Clutches for aircraft, automotive and various industrial applications

FORMSPRAG COMPANY

23585 Hoover Road, Warren (Detroit), Mich.

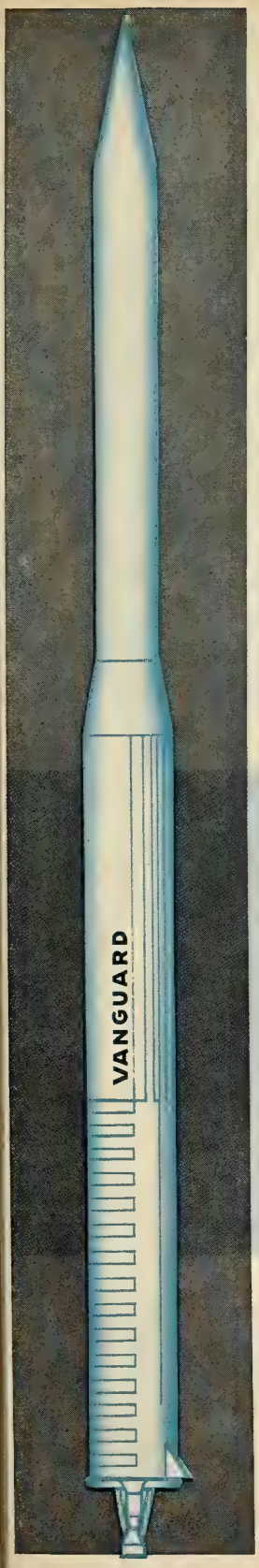
World's largest exclusive manufacturer of over-running clutches

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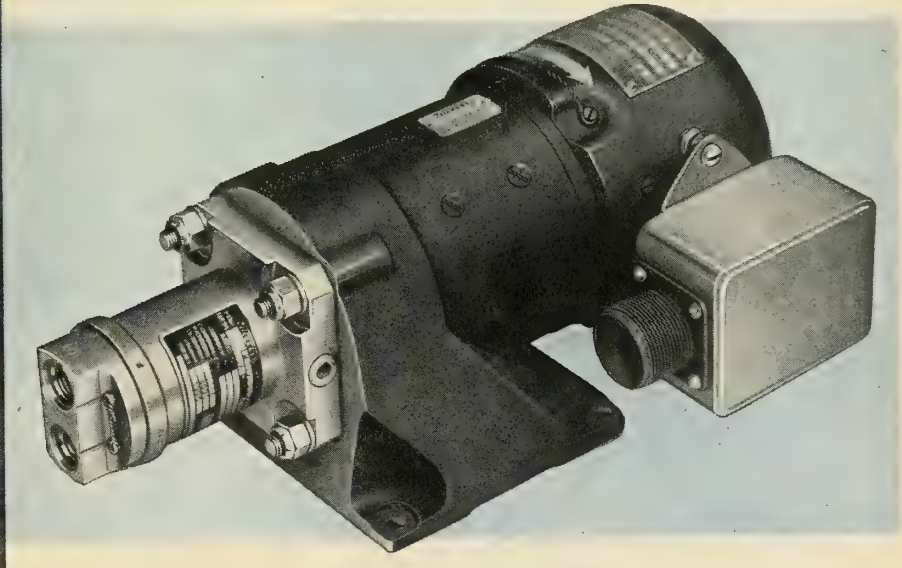
VICKERS

miniaturized motorpumps

...for Vanguard Earth Satellite Rocket Vehicle

Numerous Vickers miniaturized hydraulic airborne components have been successfully developed for missile use without sacrifice of their inherent high efficiency and reliability. Representative of the "packaged" approach to dependable missile hydraulic power is the PFM-3906 constant displacement piston type pump shown here mounted on an electric motor. The pump has a theoretical delivery of 0.84 gpm at 7400 rpm and 1000 psi with a volumetric efficiency of 95%. The explosion proof motor has 6.0 in.-lb. torque from 6900 to 9000 rpm. The complete package weighs 8 lb. . . . 1 lb. for the hydraulic pump and 7 lb. for the electric motor. **The overall length is less than 10 inches.** For further information about Vickers miniaturized hydraulic components and complete packages, ask for Bulletin A-5216.

7886



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DIVISION OF SPERRY RAND CORPORATION

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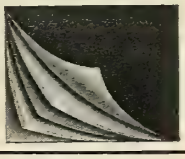
REFRASIL "Pre-Formed" and "Wrap-around" Insulating Blankets are preferred by the majority of aircraft and jet engine manufacturers all over the world!



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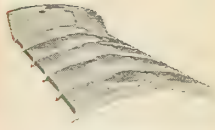


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THOMPSOglas
Formed High-Density Fiberglas is designed for Thermal and Acoustical Insulation, and is a versatile protective insulation Material for a variety of Aircraft and Missile applications.





REINFORCED PLASTICS
For Military, Industrial and Commercial Products. REFRASIL Cloth, combined with High Temp Resins, is possible liner for Missile uses. Typical High Temp Aircraft parts shown.

HITCORE Honeycomb
In Stainless Steel and a variety of other materials. Various thicknesses, core sizes and foil gages can be combined to meet your special requirements.



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Power for the world's mightiest weapons:

ATLAS • THOR • JUPITER • REDSTONE

These are the names of the great new missiles of America—defense systems of unprecedented speed and striking power. To feed their monstrous thirst for power, a new kind of engine had to be created—an engine with enough propulsive thrust to drive tons of projectile in a colossal arc upward from the earth's surface to the bounds of atmosphere, and on through space itself at thousands of miles per hour.

The answer was the large, liquid propellant rocket engine. Only a few years ago ROCKETDYNE, directed by the Air Force, set out on a program to design and build these high-thrust propulsion systems—a job that meant starting from scratch, and writing the book as they went along.

Today, ROCKETDYNE can report that the power for these revolutionary new weapons is ready. Engines for the Armed Services' high priority missile programs are being built in quantity at two ROCKETDYNE plants—Canoga Park, Calif., and Neosho, Mo.

The possession of such weapons is of crucial importance to America. Free men everywhere are entitled to know that the power for our major missiles is being delivered—on schedule.

BUILDERS OF POWER FOR OUTER SPACE

ROCKETDYNE

CANOGA PARK, CALIF. & NEOSHO, MO. • A DIVISION OF NORTH AMERICAN AVIATION, INC.

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New Design Trends for

Harvey Aluminum Extrusions

To any experienced engineer or designer, aluminum extrusions are a common commodity. You don't have to tell him that extrusions offer such advantages as ease of fabrication, design flexibility, etc. He knows that. What he wants to know now are the newest advances made possible by the extrusion process.

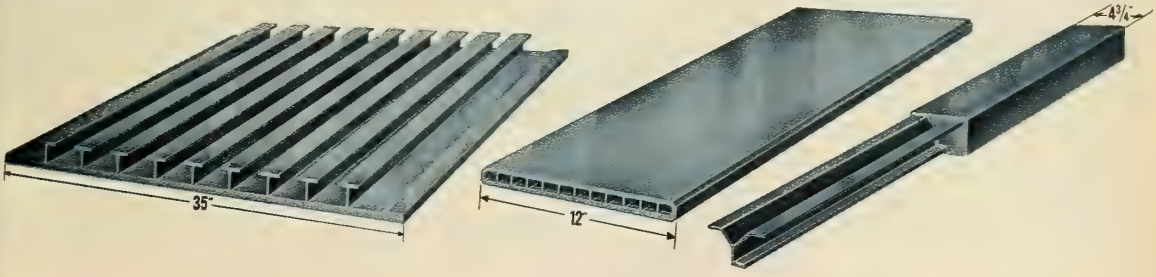
Potential for new configurations and applications

Typical new applications for Harvey Aluminum Extrusions are illustrated below. The design possibilities for aluminum extrusions are now practically limitless. Large heavy press sections; unusually complex shapes; wide, integrally stiffened skin panels; solid, hollow, and stepped extrusions; and extra long thin sections can be obtained from Harvey in all aluminum alloys. Heat-treated shapes can be produced in lengths up to 80 feet, weighing as much as 2,500 pounds. The maximum circumscribing circle diameter practical is 25½ inches. For functional, structural, or decorative applications demanding custom design plus light weight, corrosion resistance, high strength, and a naturally attractive finish, Harvey Aluminum Extrusions are first choice. And remember, Harvey is traditional for high quality and service.

Harvey Aluminum leads in extrusions

Harvey's completely integrated facilities include a large complement of extrusion presses ranging in size from 1400 tons to 12,000 tons, stretch-straighteners up to 3,000,000 pounds capacity for lengths up to 105 feet, and the newest supporting and finishing equipment.

If you have a problem with extrusions, thoroughly qualified Harvey specialists are always ready to help you improve your product. Write to Harvey Aluminum Sales, Inc., Torrance, California, or contact the nearest sales office listed under "Aluminum" in your classified telephone directory.



INTEGRALLY STIFFENED SKIN PANEL is produced in extra wide widths on heavy presses. Combination of skin and stiffeners in large panels minimizes machining, simplifies assembly, improves performance of aircraft, missiles, and military vehicles.

DECK COOLING PANEL for aircraft carrier is extruded on heavy presses. Light-weight, water-tight aluminum panels circulate water to offset intense heat generated against deck in jet aircraft operations.

STEPPED EXTRUSION for aircraft structural member eliminates machining and reduces assembly time. Aluminum part is lighter and stronger than outmoded built-up section formerly used.

Making the most of aluminum . . . for everyone

HARVEY ALUMINUM SALES INC., TORRANCE, CALIFORNIA

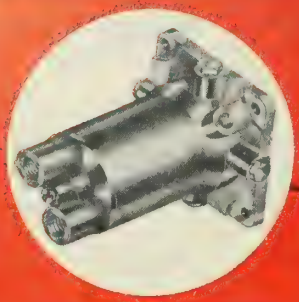
HARVEY Aluminum

Harvey is a leading independent producer of quality aluminum products in all alloys and sizes: Rod and bar, pipe, tube, hollow sections, press forgings, forging stock, impact extrusions, structurals, special shapes, extrusions, screw machine products and other aluminum products. Harvey is also producing similar items in titanium and steel.

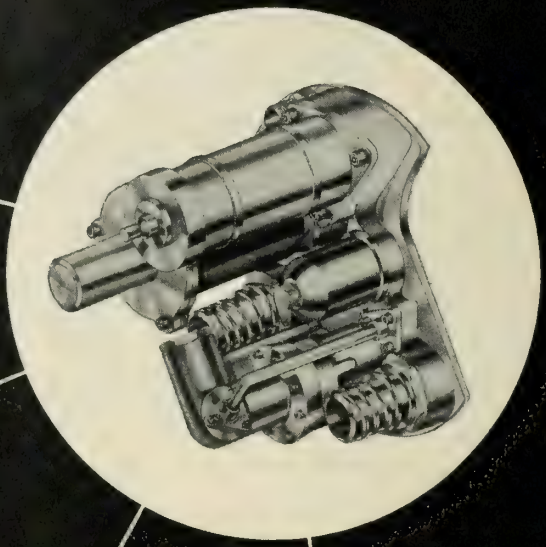
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by STRATOPOWER®

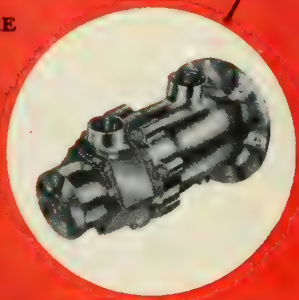


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HIGH TEMPERATURE ACCUMULATORS



HYDRAULIC PUMPS



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Package design provides optimum operation, minimum weight and maximum reliability by eliminating a major hydraulic problem . . . interconnection of dissimilar units. Design matching and manifolding of all components by the manufacturer simplifies trouble shooting. Your package comes as a unit, tests as a unit and works as a unit.

Package design by STRATOPOWER offers one source responsibility of design, development and manufacture.

As one of the largest manufacturers devoted *exclusively* to aircraft hydraulic accessories, STRATOPOWER is already volume producing many components at the rate of thousands per month. By combining these installation-proven components with other parts still in development stages, STRATOPOWER can complete *your* package for early delivery. For further information, contact The New York Air Brake Company at the STRATOPOWER Sales and Service office nearest you.

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At DOUGLAS, you'll work to expand the frontiers of knowledge in today's most advanced missiles program



1. Nike 2. Honest John 3. Sparrow 4. Thor IRBM 5. Secret 6. Secret 7. Secret 8. Secret

It's no secret that we're in the "missile business" to stay . . . with sixteen years behind us and an ever-expanding future ahead

There can be no mightier challenge than to be assigned to any one of the major projects now under way in the Douglas Missiles Division.

Some – like Nike and Honest John – have pioneered missile development. Others on which Douglas engineers are engaged are extending the horizons of present-day development . . . cannot be mentioned for reasons of national security.

These are the projects that require engineers who are looking far beyond tomorrow. You will use all of your talents at Douglas and have the opportunity to expand them. Your only limitations will be of your own making. Douglas is an engineer's company . . . run by engineers. Make it your working home and build an important and rewarding future in your field.

For complete information, write:

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GO FURTHER WITH DOUGLAS

FIRST IN AVIATION



Genisco G-Accelerators play vital role in ICBM development

Threading the needle half-way round the world leaves no room for error.

Inertial guidance—self-contained guidance systems used to direct huge ICBM's to the target—depends for its accuracy upon the degree of internal instrumentation perfection. Switches, relays, delicate instruments, and hydraulic and electrical systems must operate perfectly—even while subjected to tremendous acceleration forces.

Testing components and complete asssemblies to simulated operational G-forces, as required by MIL-E-5272A, before relying upon their operation in actual flight is easily accomplished with Genisco's G-Accelerators.

Genisco's precision centrifuges are available in five standard sizes—from high-speed machines capable of high G-loadings, to large 12-foot diameter machines capable of accommodating complete electronic or electromechanical systems.

All models incorporate features necessary for critical laboratory testing, as well as the ruggedness and simplicity of operation required for production-line test programs.

Many automatic features minimize operator responsibility and chance for error. Built-in safety features and integrity of construction provide maximum protection to both personnel and machine.

Complete specifications on all machines and accessories are available. *Write, outlining your specific requirements.*



MODEL B78
Accommodates test objects up to 25 pounds; 1200 G-pounds max.



MODEL C159
Accommodates 100-pound test object on each end of boom; 2000 G-pounds max.

MODEL D184
Range of 1 to 800 G's; 1000 G-pounds max.



MODEL E185
Subjects two 300-pound assemblies to 100 G's. 30,000 G-pounds max.

Genisco INCORPORATED

reliability first

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Los Angeles 64, California

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MISSILE ELECTRONICS
Another AAP First

Sums up to one half of this nation's missile expenditures are invested in the *electronics* part of the business. With new, sophisticated guidance, tracking and computing systems under way, missiles will become more efficient, yet more complex. Thousands of engineers today—and many more thousands tomorrow—will put their efforts into *missile electronics* for the sake of advancing missile guidance, tracking, telemetry, data reduction, computing.

These thousands of engineers—comprising the *missile electronics* business—have not been adequately served. After an extensive survey American Aviation Publications, Inc. has decided to meet this challenge. It has decided to cover the missile electronics market and its engineers and management personnel with an up-to-date exclusive and extensive monthly presentation titled MISSILE ELECTRONICS, starting October 1957.

This "magazine"—a supplement to MISSILES & ROCKETS—will be published as a separate section within MISSILES & ROCKETS—at no additional cost to our subscribers. The two-magazine-in-one approach to the vast missile and astronautics field will enable us to serve our readers better, in that we will cover the entire field to the very utmost extent.

For this important expansion program American Aviation Publications, Inc., the world's largest aviation and astronautics publishers, will again increase its staff of top-notch editors. Needless to say, MISSILE ELECTRONICS and its readers will benefit from our worldwide staff facilities.

Your comments and suggestions as to how we can make MISSILE ELECTRONICS useful to you would be welcomed and appreciated.

Watch for the first issue, next month—October.

WAYNE W. PARRISH,
President and Publisher,
American Aviation Publications, Inc.



Shock wave around a simulated missile

SUPERALLOYS for supersonic performance

We develop them. And through modern vacuum melting produce them to the closest possible limits of chemical control and uniformity of mechanical properties for use in such critical components as aircraft turbine blades, buckets and skin material for missiles and rockets. UDIMET 500, one of our well established vacuum melted alloys, combines unsurpassed stress-rupture life with excellent ductility and fatigue strength in the 1200°F to 1800°F range. At 1200°F, for example, its tensile strength is 180,000 psi —at 1600°F, 100,000 psi. For further information concerning applications of these superalloys to your products, write to address below.

VACUUM MELTING
provides these properties

- *High temperature corrosion resistance*
- *Increased ductility*
- *Extreme cleanliness*
- *Precise chemical control*
- *Longer stress-rupture life*
- *Increased tensile strength*
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- *Greater yield strength*
- *Greater impact resistance*
- *Greater creep properties*

UTICA METALS DIVISION OF KELSEY-HAYES

UTICA DROP FORGE & TOOL DIVISION U DI MET® ALLOYS KELSEY-HAYES CO., UTICA 4, NEW YORK

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IS YOUR JET ENGINE RPM MEASUREMENT ACCURATE AND SAFE?

TAKCAL®

READS JET ENGINE SPEED to GUARANTEED ACCURACY of 10 RPM in 10,000 RPM (±0.1%)

The inter-relation of RPM to efficiency and thrust in jet engines is fundamental. Proper adjustments for maximum thrust, maximum engine life and maximum safety of operation can be made only upon accuracy of instrumentation. The TAKCAL tests to guarantee that accuracy.

The new B & H TAKCAL incorporates a refinement of the frequency meter principle. It operates in the low (0 to 1000 cps) range, reading the frequency of the tachometer generator on a scale calibrated in percent RPM corresponding to the engine's RPM. It reads engine speed while the engine is running with a guaranteed accuracy of ±0.1% in the range of 0 to 110% RPM. Additionally, the TAKCAL circuit can be used to trouble-shoot and isolate errors in the aircraft tachometer system, with the circuit and tachometer paralleled to obtain simultaneous reading.

The TAKCAL's component parts are identical with those used in the J-Model JETCAL Analyzer. They are here assembled as a separate unit tester and for use with all earlier models of the JETCAL Tester.

The TAKCAL operates accurately in all ambient temperatures from −40°F. to 140°F. Low in cost for an instrument of such extreme accuracy, it is adaptable to application in many other fields.

For full information write or wire...



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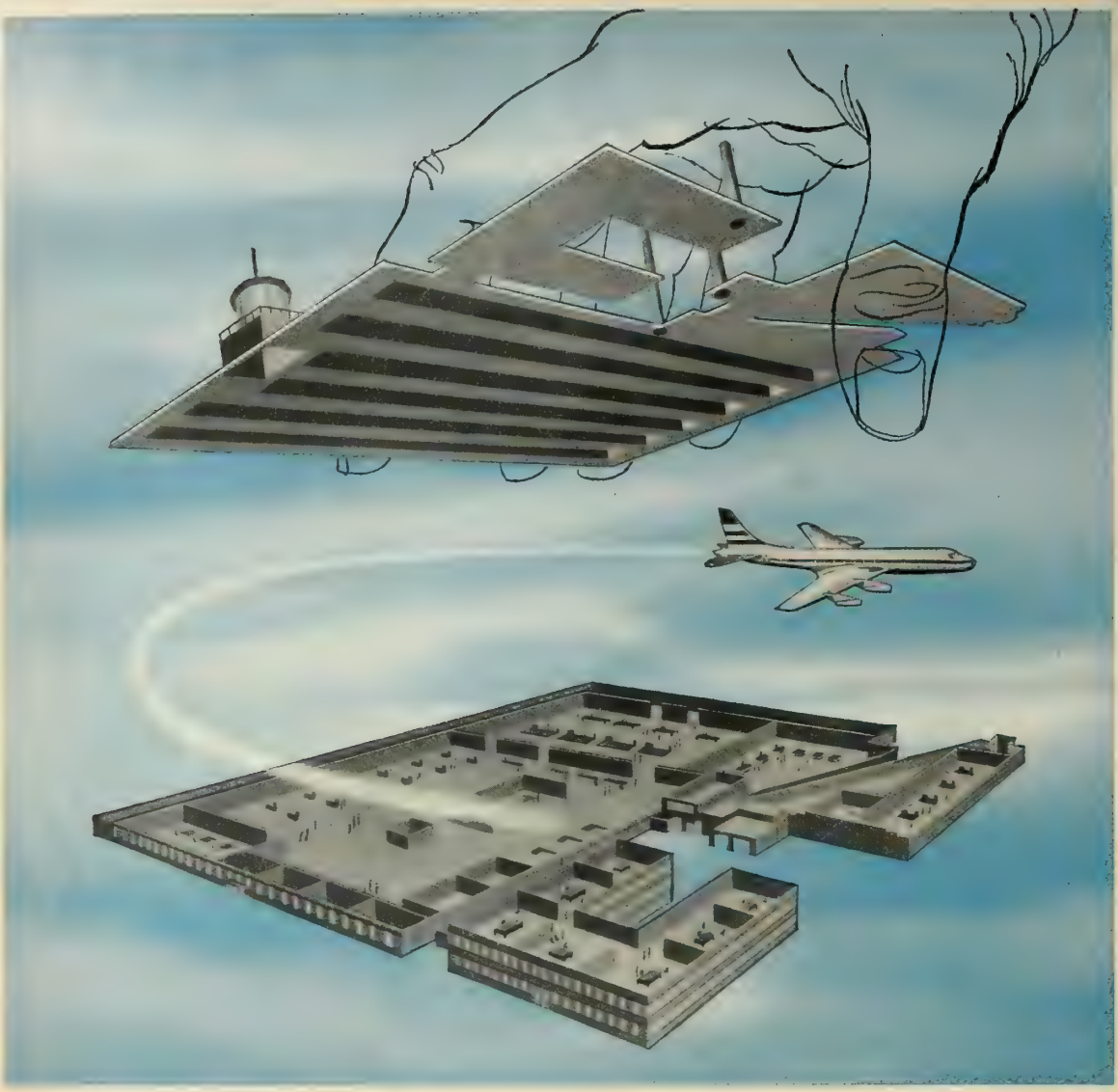
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Soviet IRBMs, ICBMs Jolt U.S.

A Soviet count-downer recently pushed a button that fired a ballistic missile probably between the small missile-launching island of Kolguev in the Arctic near Novaya Zemlya, and the Northwest Pacific Sea of Okhotsk—apparently the first intercontinental ballistic weapon anywhere in the world to go the distance (over 3000 miles). Furthermore m/r learns from reliable Norwegian sources that the Reds have been launching intermediate range ballistic missiles from naval ships in arctic waters for some months and continue to do so. And while the Reds were impressing their missile prowess on the world, a group of top U.S. missile producers met in Washington and formed the National Guided Missile Industry Conference with an avowed purpose "of putting the U.S. missile effort on a more rational basis."

On that Monday evening when the first banner headlines of Russia's ICBM capability blared across the nation's front pages, none of the missile businessmen had forecast Soviet ascendancy in long-range missiles, but frustration and premonition were common to everyone present—"We need missiles, not politics and false economy."

On what indeed may be a fateful evening in world history, these representatives of American competitive free enterprise decided that they, if nobody else, would try to put order and efficiency into the U.S. missile effort. They are convinced missiles require a different approach from aircraft.

Those in at the founding represent some of the most successful names in missiles today—boast contracts on such important projects as *Titan, Polaris,* the *Nike* series, *Lacrosse, Talos, Falcon,* and *Hawk.*

Their organization will work, within the limits of security, to air basic guided missile problems and their solution before Congress and the American public; and to spread vital missile know-how throughout the guided missile industry. A secondary, but still important emphasis of the group will be to push producibility (low cost) as well as availability and reliability of "in-service" missiles.

In recent history, the record shows, the Russians have never made an announcement such as this on the ICBM, without there being a sound basis of fact. Announcements of Soviet A-bomb and H-bomb achievements are good examples of this. Besides, the ICBM is not a big step from the IRBM—and they have been firing these with alarming regularity.

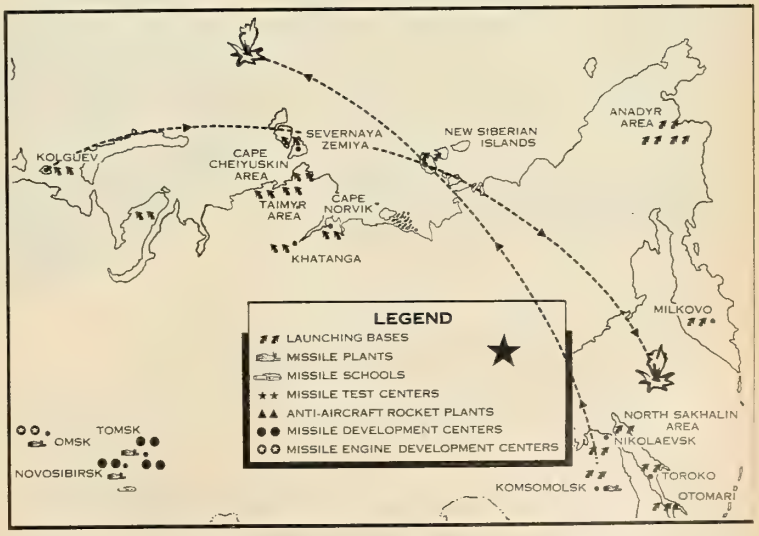
The official TASS ICBM announcement, as quoted in a Radio Moscow news broadcast monitored by m/r describing the missile as an "over-continental ballistic missile, capable of delivering a nuclear warhead anywhere in the world." The difference between "inter-continental" and "over-continental" isn't clear, but it could imply a range over the standard U.S. ICBM figure of 5000 miles or could merely have been a way of stating that the missile was tested over the Russian land mass. A tip-off to Western intelligence sources that something big was brewing could have been the Soviet warning a short while back for all foreign shipping to stay clear of the Sea of Okhotsk, north of Vladivostok.

Furthermore, a U.S. missile engineer just returned from Russia within the last few days insists that the Reds will launch an artificial earth satellite before the end of September—probably on Sept. 17, the 100th anniversary of Tsiolkovsky's birth. Konstantin Tsiolkovsky is generaly recognized as "the father of space flight" for his proposals on reaction-powered space flight before the turn of the century.

Meanwhile, Scandinavian fishermen report having witnessed several Soviet shipboard IRBM launchings this summer. First reports of such firings over a year ago suggested that the missiles involved were Russia's 700-mile ballistic missile, the *Comet.* More recent reports indicate the missiles may now have a much greater range—could possibly be the 1800-mile T-2 (M-103).

Norwegian sources told m/r the firings take place at night under bright midnight-sun conditions when visibility and optical tracking are perfect. In addition, Russia is known to have missile-launching sites on the Kolski peninsula as well as near Novaya Zemlya. Reports have not been confirmed whether Russia has launched any big missiles from these land sites. Sea launching is considered, however, to be much more difficult. The U.S. has still not launched any ballistic weapons from shipboard.

As reported in previous issues of m/r Russia's long-range ballistic missile knowhow probably is on a par with ours. Their guidance systems might be cruder, but their production output is in high gear. Ours is not. Apparently, the Reds believe in a vast amount of crude missiles rather than a few with pin-point accuracy.



Possible flight paths of the Russian ICBM firing is depicted by dotted lines. The more probable impact point is the Sea of Okhotsk (lower right) recently closed to shipping.

Spectre: First Throttleable Production Rocket

LONDON—(JAMES HAY STEVENS) In offering the *Spectre* as a production HTP/kerosene rocket, The de Havilland Engine Co. claims seven special advantages for the propellant choice: (1) automatic thermal ignition—but *not* spontaneous combustion; (2) catalytic decomposition of all HTP entering engine—i.e. avoidance of liquid injection with its explosion risk; (3) low-loss turbine drive for propellant pumps—its exhaust is used as part of oxidant; (4) controlled variable output over wide thrust range —idling less than 5% of max.; (5) ability to stop and re-start indefinitely; (6) foolproof—designed as an airplane engine with safety and long life; and (7) self-contained—propellant pumps and starting system are in the engine and it uses turbojet fuel.

Although the first practical airplane rocket—the *Walter* 509 in the WW-II Me 163 intercepter—was controllable, the *Spectre* is the first modern rocket to be throttle-operated, as distinct from multi-barrel thrust controlled.

Development by DH has continued for about ten years, starting with the *Sprite* ATO unit for the *Comet* 1. This was a 'cold' HTP unit, using solely the energy released by catalytic decomposition into oxygen and superheated steam at 1,100°F (600°C), publicly demonstrated at the 1952 SBAC Display. Next step was the *Super Sprite* 4000 lbs. x 40 sec. ATO pack for the Vickers *Valiant*, which burns the decomposition products with kerosene.

Design and prototype construction of the *Spectre* took about two years, with the first bench run in July 1953. This run was "cold"; the first "hot" run not being made until the early fall, an acceptance test being made within a month. Design rating of the *Spectre* D.Spe.1 was reached in July 1954. A water-cooled reaction chamber and nozzle were used for these early runs, but in November 1954 this was discarded and the engine was run continuously for more than one hour, using only the integral HTP cooling system.

Initial flight trials in the belly of an English Electric *Canberra* (B-57) started cold last December, with the first hot firings in January. Ground firings in the tail unit of a Saro S.R.53 were carried out in a rig at Hatfield before the airplane itself flew on May 16.

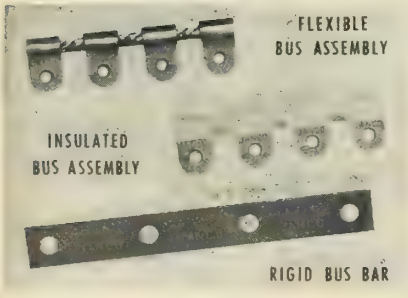
The advantages of being able to use the same fuel as a turbojet are obvious in terms of flight plan flexibility and tactical supply in the field. HTP is, at present, expensive to manufacture, but the method lends itself to mass production as economical as other oxidants. A practical design feature is that the flame temperature of HTP/kerosene not only peaks at the Stoichiometric ratio, which means cold running in the event of control valve failure, but its value of around 3600°F (2000°C) is about the limit for present materials.

The *Spectre* is now on British Security's Initial Publication List, which means only externally obvious features are revealed—dimensions but neither weights nor performance.

It is a compact, completely self-contained engine 56.5 in. long, 26.5 in. in diameter. The installation di-

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ameter over the three-point thrust mounting is 32 in. The reaction-chamber/expansion-nozzle assembly scales 44 in. long, with an overall diameter of about 13 in. and a nozzle lip diameter of some 10 in. The HTP supply pipe is nearly 2 in. in diameter, that for the fuel, over 1 in.

The cylindrical reaction-chamber-/expansion-nozzle assembly is bolted together from three sub-units—a forward end, ribbed central body and the rear casing, which is almost half the engine length. In order to achieve efficient combustion over a wide thrust range, it is necessary to use a high pressure, around 500 lb/sq. in., hence the ribbing.

The front of the *Spectre* is a gearbox casing with a large oil sump having a filler and sight level glass on the left side. The position of the gearbox suggests a turbine drive in the head of the reaction chamber, probably of impulse type and energized by a portion of the catalyzed HTP.

At the front of the gearbox is a vane-type, high rpm centrifugal pump, which delivers HTP into a pipe running along the top of the nozzle casing. Beneath the fore part of the casing, there is a smaller external pipe leading to the head of the reaction chamber.

Kerosene is delivered by a centrifugal vane pump on the left side of the gearbox to a cylindrical fuel-cooled oil cooler on the right side, after which it again traverses the engine to a valve unit on the left side of the reaction chamber.

Most of the control cranks and the various sequencing valves are on the left side of the engine. On the right, is a spherical accumulator mounted atop a pump/valve unit with a manual actuating unit. Pipes lead from the inlet side of the HTP pump to the valve, thence to the top of the sphere and from there to the reaction-chamber casing.

Although performance and weight data are classified, it is known that the *Spectre* was made to the same specification as the Armstrong Siddeley *Screamer*. The latter is unclassified because it was axed when the Ministry of Supply decided to abandon LOX for manned aircraft rockets. A full development story on the *Screamer* was given by S. Allen, chief engineer of Armstrong Siddeley's Rocket Division to *The Royal Aeronautical Society* on October 11, 1956.

The *Screamer* had a design sea level static thrust range from 1000 lbs to 8000 lbs; maximum thrust at 40,000 ft of 9500 lbs.

Army to Supply Navy *Polaris* Test Motor

The U.S. Navy's *Polaris* Fleet Ballistic Missile program is still a joint Army-Navy operation—in part at least. Thiokol Chemical Corp. holds a contract from Army Ordnance to supply engines for *Polaris* test vehicles. This is in cooperation with Lockheed Aircraft Co., prime *Polaris* systems contractor. These are full-scale missiles. The firing schedule has all the earmarks of a crash program, with actual flight tests to begin this fall. This means Navy's already well ahead of previously announced targets for getting an operational FBM.

Navy, apparently, is taking full advantage of the knowhow that has been accumulated by ABMA at Huntsville, Ala. Though Aerojet-General Corp. is officially designated as the *Polaris* rocket motor contractor, it is not beyond the realm of possibility that Navy is running a competitive development program as between Thiokol and Aerojet to see who comes up with the best solution to *Polaris* propulsion problems. If so, look for a later determination between the two, as to just which one gets the final production contract.

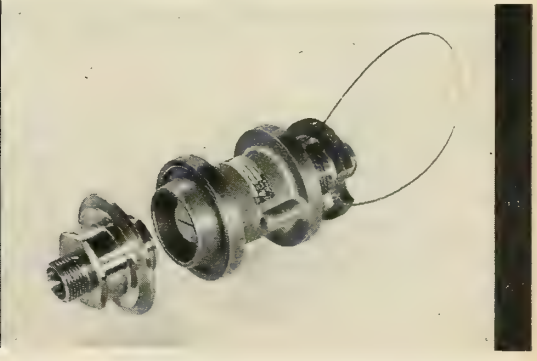
Little information is available as to the exact nature of the *Polaris* missile, except that it is to be a 1500-nautical-mile ballistic missile, capable of being fired from either surface ship or a submerged submarine. It will be powered by a solid-propellant motor and be about eight feet in diameter and 40-to-45 feet long. Every effort will be made to keep its length down, including such devices as the use of multiple exhaust nozzles, say, four instead of one. This configuration offers other advantages as well, such as: imparting spin by canting the nozzles; enabling any number of nozzles to be fired as desired; and a possible gain in efficiency as more complete burning is achieved in the plenum chamber.

Stromberg-Carlson Opens New Facility

Stromberg-Carlson, a division of General Dynamics Corp., has opened its new administration building and recently purchased electronics center at Rochester, N. Y. The facilities provide an additional million sq. ft. to the company's expanding telecommunication and electronics business.

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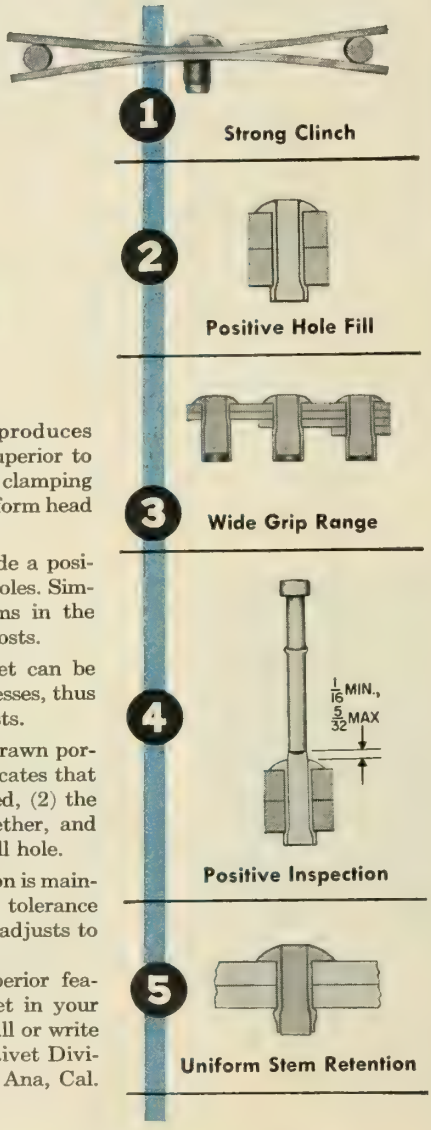
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Underground Factory In the Works?

HUNTSVILLE, Ala.—A series of obscure real estate transactions is now nearing completion here. Execution of the final deed to some remote mountain property on the big bend of the Tennessee River is expected to clear the way for start of a much-discussed but little publicized project believed to involve American Machine & Foundry Co., Redstone Arsenal and the Army Ballistic Missile Agency. (See m/r, May '57).

For almost two years now, a group of citizens who work to bring new industries into this area has been quietly buying up, in their own names or through proxies, various parcels of land scattered about nearby Green Mountain. This is a big ridge, about 1500 feet high and five miles long, a part of the Blue Ridge-Smoky range that cuts across Northeast Alabama to Birmingham. Green Mountain lies across U.S. Highways 231-431 from Redstone Arsenal and stops at the very edge of the Tennessee River.

The men who have been buying up the tracts of land on Green Mountain are all members of the Huntsville Industrial Expansion Committee. The city being what it is—a rapidly-expanding missile and rocket center—it has been impossible to conduct such operations in secrecy.

There have been persistent reports that AMF is planning some kind of

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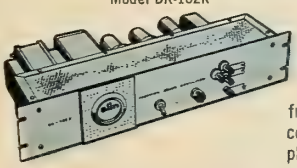
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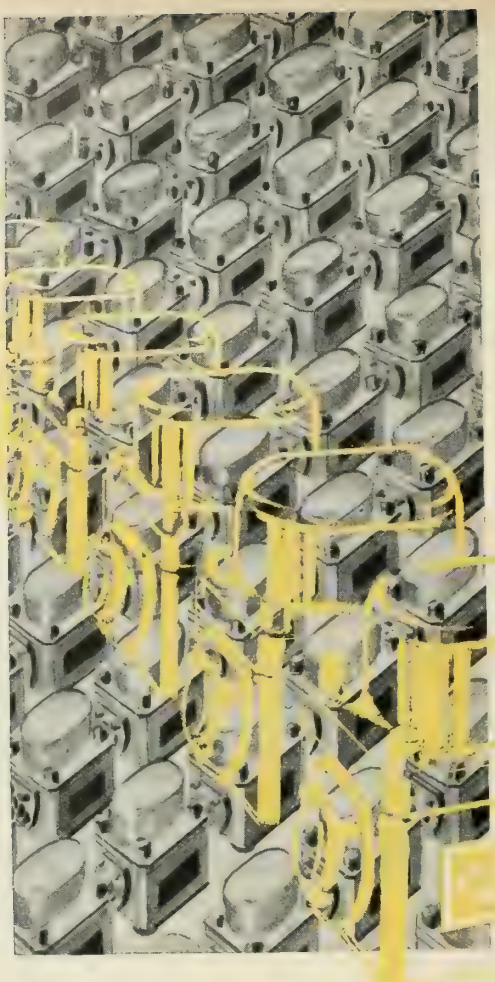
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underground factory in the mountain, perhaps for the manufacture of missiles, rockets and components. AMF officials are here periodically for closed sessions with officers at Redstone and ABMA and the Industrial Expansion Committee. None will say anything publicly about the Green Mountain reports; neither has anyone denied them.

The latest acquisition of some 35-40 tracts is said to clear the big promontory for whatever purposes are in mind, although there is another report that one more tract remains to be purchased—one that is legally complicated because it involves property that passed to the Alabama State Board of Education under a will. This transaction, however, is said to be virtually completed.

Earlier this year the same group negotiated the purchase of some 200 acres on the river at the very end of Green Mountain. This is now to become the site of new state docks, presumably to serve the new installation and also to help cart away the vast quantities of limestone that must be excavated if the factory is to be built.

Informed sources say that some explanation of all the mysterious moves in and around the mountain may come within six months.

Missile Submarine Launched at Mare Island

The Navy's first submarine built primarily as a guided-missile sub was launched in June at the Mare Island Naval Shipyard. Capable of handling the *Regulus* missiles, the *Grayback* (SSG 574) is scheduled to join the fleet in July, 1958.

The two submarines now operating with the fleet as guided-missile subs, *Barbero* and *Tunny*, were converted to missile-carrying subs after first operating as conventional submarines. Two others being constructed are the *Growler*, a conventional powered submarine and the *Halibut*, the Navy's first guided-missile, nuclear powered submarine, and the first ever designed from the keel up as a guided-missile carrier.

Funds for three additional nuclear-powered guided-missile submarines have been requested in the fiscal 1958 budget.

Gilfillan Receives *Corporal* Contract

Gilfillan Brothers, Inc. has received a $695,000 contract for *Corporal* ground guidance improvement, it has been announced by the Department of Commerce.

Big B Rocket May be Major Breakthrough

Primarily Army's *Big-B* and *Big-B Junior* programs involve major developments in solid rocket propulsion. Whether the knowhow is applied to a 2000-mile missile, a 750-mile missile or a 12,000-mile missile is, for the moment, academic.

The most important point is that by the application of wholly new techniques to conventional solid propellants, considerable gains in mass ratio as well as thrust, and possibly specific impulse, are expected. Details of just what these techniques are, is a closely guarded secret. It is known, however, that from a manufacturing point of view, there are no really thorny problems in the way of rapid progress. Static tests of the first motors are expected to take place within a few weeks.

Once the new state of the art has been proved out, solid propellants for large-missile applications will hold a much more competitive position with the liquid rocket engines that are now doing the big jobs. Doing this work is Thiokol Chemical Corp. at Huntsville, Ala. This solid propellant breakthrough is believed to involve several simultaneous approaches to different problems. One is believed to be concerned with a new appreciation of the old principle of several smaller nozzles replacing one and firing out of a high-pressure plenum chamber—such as Thiokol is supplying on its *Polaris* test vehicle motors.

Electronics Spending Predicted at $3.5 Billion

Military spending for electronics may reach the $3.5 billion level by the end of the current fiscal year, according to an estimate made by the Radio-Electronics - Television Manufacturers Association. This will top by $700 million fiscal 1956's $2.8 billion expenditures.

The estimate is based on the premise that fourth quarter government spending often approaches 60% of the total of the three preceding quarters. Through the first three quarters this fiscal year military spent $2,492 million.

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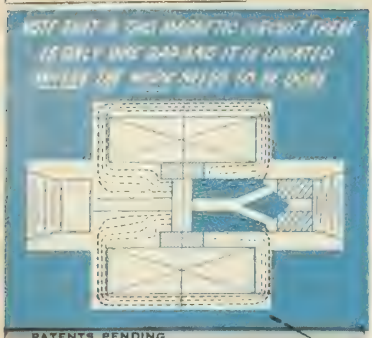
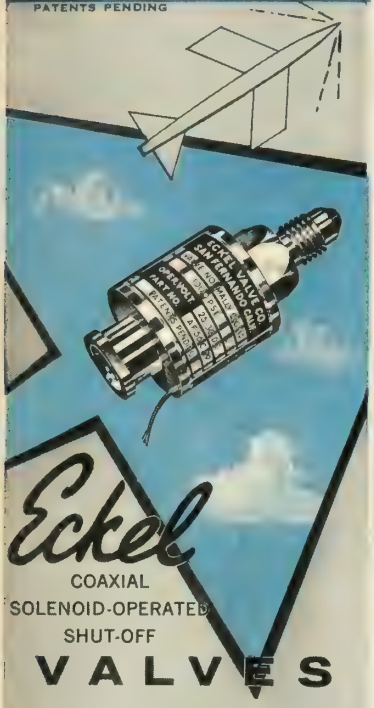
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New Building Spurs Payroll at Redstone

HUNTSVILLE, Ala.—July's new construction contracts awarded at Redstone Arsenal, Army Ballistic Missile Agency and Ordnance Guided Missile School bring the value of the building program now under way at this huge Army rocket and missile center to more than $24 million.

Temporary employment of some 1500 persons on the new projects has boosted the work force at the three installations to almost 16,000, the highest total in its history. More than 14,500 people are working permanently at the three agencies.

Largest of the new projects involves five buildings for the Missile School—three classroom and laboratory structures and two shop buildings costing nearly $4 million. Blount Bros. Construction Co. of Montgomery, Ala., contracted to complete this project by June 1958 in time for the slated expansion of the Missile School from its present 1750 students to 3500 in 1958.

Other new structures at ABMA include: a missile surface treatment facility, an acceptance test and qualification building and an engineering mission support building.

In varying stages of construction now are: three static testing service buildings, a $4,280,000 four-building complex for structures and mechanics use, a guided missile test shop, a missile assembly and inspection hangar, an addition to a structural fabrication laboratory and 270 family housing units.

400 Days to Reach Mars Army Scientist Says

HUNTSVILLE, Ala.—The first projected time table for travel to and from Mars has been set by Dr. Gilford G. Quarles, scientific consultant at Army Ballistic Missile Agency here.

An ionic propulsion ship, using an earth satellite platform, would require 400 days to reach Mars, he says while the return trip would take 300 days.

"Although interstellar travel must await the development of more efficient propulsion systems, such as the photonic system, interplanetary travel is definitely within the scope of present technological feasibility," he declared.

"Daffynitions" Amuse Redstone

In the wake of Dave Morrah's *Saturday Evening Post* comic series on the mixture of German and English terms invented by his fictitious Herr Schnibbel, it was inevitable that the close co-operation between former German scientists and U.S. missile men at Redstone Arsenal should result in their own glossary of terms. Here are some "daffynitions" concocted by bi-lingual jokesters:

guided missile—das skientifiker geshutenwerke firenkrakker
rocket engine—firesphitter mit schmoken-und-schnorten
nuclear warhead—das eargeschplitten loundenboomer
celestial guidance—das skrewbalische schtargazen peepenglasser mit komputenrattacen schteerenwerke
engineering department—das aufguefen grupe
project engineer—das schwettenouder
structural test engineers—das pullenapardten grupe
security detail—das schnoopen bunche
hydrogen device—das eargeschplitten laudenboomer mit ein grosse hollengraund und alles kaput.

Amoco Solid Rocket Plant Nears Completion

Amoco Chemical Corp.'s new factory at Seymour, Ind., for the manufacture of solid-propellant starters for jet engines, is expected to be finished this November. Standard Oil Co. of Indiana, a pioneer in ammonia-based propellants, did the original research work leading to development of the solid propellant starters. The $3.5-million Air Force production contract for 300,000 of the units is handled by Standard's subsidiary, Amoco Chemical Corp.

Meanwhile, Standard's Research Laboratories at Whiting, Ind., and Seymour are continuing work under Air Force contracts on solid-propellant grain sizes for various purposes.

Martin Announces Missile Cooling System

Baltimore, Md.—At a press conference last week the Martin Co. disclosed the development of an advanced missile cooling system. System was designed to combat heating from aerodynamic friction in high-speed flight and electronic components.

Main feature of the system is the use of water as a cooling medium instead of the frequently used ammonia systems. Martin announced that the system has undergone one year of ground testing with an excellent performance record. Advantages over present cooling systems is its compact size, low cost and ease of manufacture.

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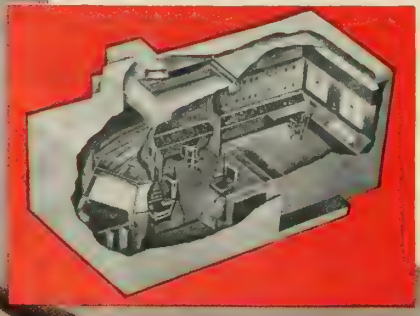
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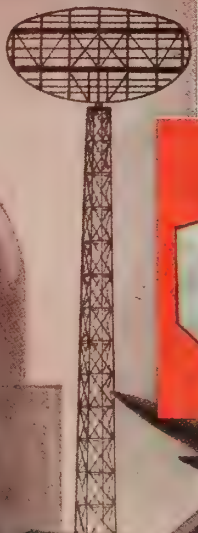
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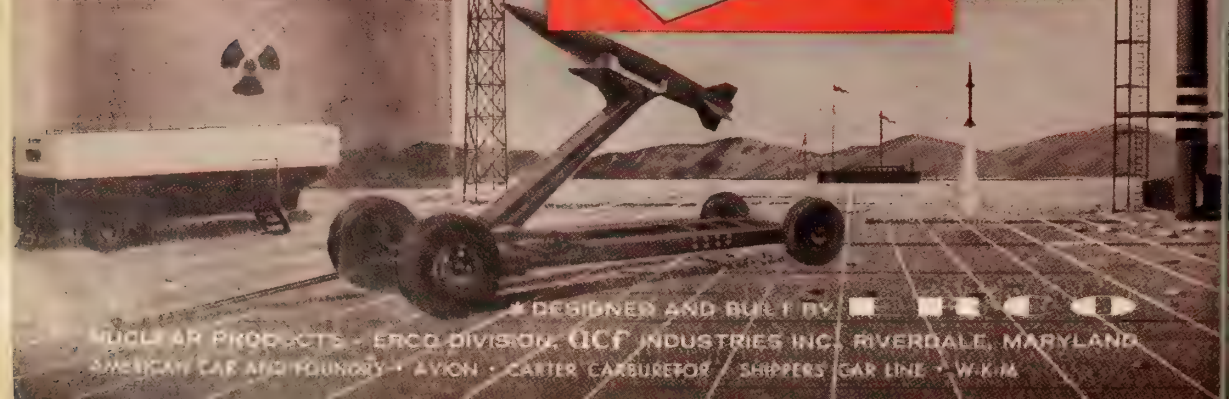












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Jupiter Guidance Hits 99.98% Accuracy

A *Jupiter-C* test vehicle, consisting of a *Redstone* first stage, cluster of *Recruits* second stage and another cluster of *Recruits* third stage, recently flew 1200 miles and landed within 400 yards of its target. That works out to about a 0.02 per cent miss error—or 99.98 per cent accuracy.

This was the Army rocket flight that also achieved a 400-mile altitude and a reentry velocity of 12,000 miles per hour. Just prior to the warhead hitting the Atlantic, a capsule was ejected containing a letter addressed to Maj. Gen. John B. Medaris, Commanding, Army Ballistic Missile Agency. This was recovered.

The reentry velocity was in the same ballpark as that which will be faced by ICBM and IRBM warheads. It is significant that the nose cone made the reentry flight down to the ocean's surface intact. It is also significant that this nose cone is reported to have been a nonmetallic structure.

No statement, official or otherwise, has been made as to the guidance system used in this *Jupiter-C* flight. However, it seems virtually certain that it was the radio-inertial system developed under ABMA direction jointly by Jet Propulsion Laboratory and Motorola's Western Electronics Division.

More *Vanguard* Details Given to Congress

Incrementally, version by version, the story on the Project *Vanguard* satellite creeps out. With the recent request to Congress for an additional $34.2 million "to complete the project", some additional facts were put on the public record by Office of Naval Research Chief, Rear Admiral Rawson Bennett and others of his staff, including Dr. John P. Hagen, Project *Vanguard* Director, Naval Research Laboratory. Amplification and additional details, however, were placed off the record.

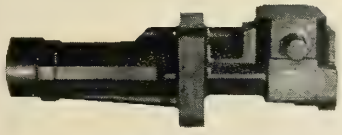
In what for a Capitol Hill committee hearing was a mild session on the record, Adm. Bennett placed the blame for rocketing *Vanguard* costs on the General Electric first-stage engine, the Aerojet-General second-stage and "some structural troubles with the vehicle itself."

Near the end of the brief hearing, Rep. George H. Mahon (D., Texas), Chairman of the House Appropriations Subcommittee on Defense Department Appropriations, asked Adm. Bennett about reports that the Army had the capability for launching an artificial earth satellite, and at considerably less cost than *Vanguard*. Adm. Bennett replied:

"I would like to answer that on the record. The Navy Department was selected by the Department of Defense on the basis of the considered recommendation of the Stewart committee, a committee of nationally known experts, to do the job. This assignment was made with complete knowledge of the work which was going on in all agencies. Therefore, we are proceeding with it as best we can. (Discussion off the record.) We were asked to do a job to further science and we are trying to do that. On that basis, we have no comment on the rumors."

Clarification on the troubles with the first-stage engine only serves to muddy the waters. Again, quoting Adm. Bennett from the hearings: "In the case of the first-stage G.E. engine,

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it seemed to burn out. A lot of work was required to find out why, and then to correct it. Briefly, the real answer was that quality control: the nozzles, the injectors, and other items were not accurately enough made so that unusual heats, that is, local heat spots in the engine, would be prevented. Once that was realized and corrected, the first-stage engine was on the beam."

This conflicts with other stories of what happened to General Electric's engine. GE engineers suggest that the trouble with the first three engines delivered to the prime contractor and rejected was as follows: In subjecting the delivered engines to hydrostatic test prior to static test firing, water of insufficient purity was used, and afterwards the engines were not properly cleaned. A period of time elapsed prior to test firing. During that period, rust spots developed which in turn resulted in hot spots and burnout.

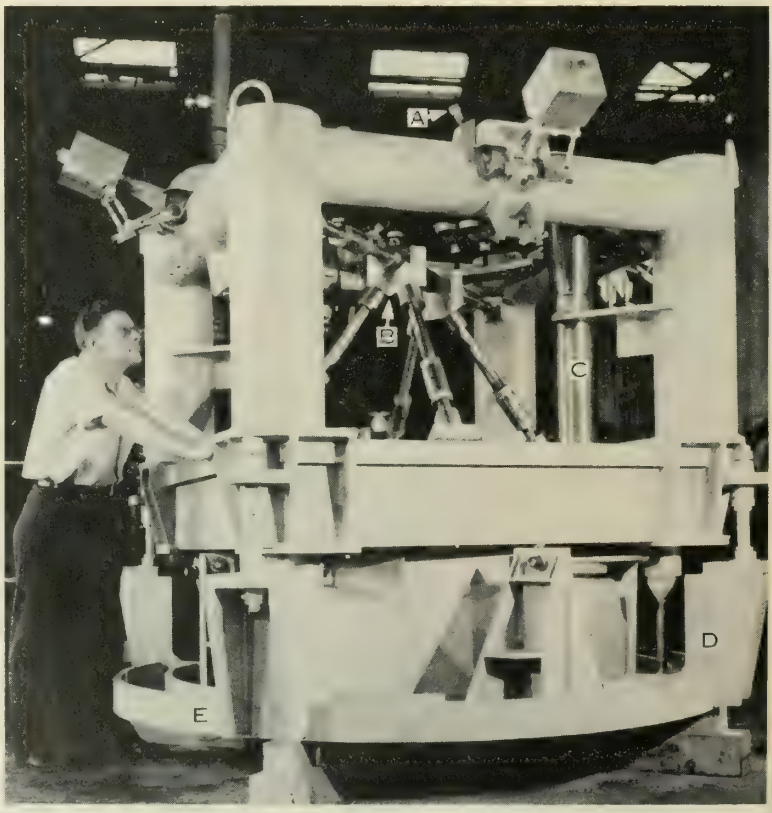
Second-stage engine experienced a similar sort of trouble which was eventually corrected. He pinned down structural problems with the vehicle as a "computational suspicion that vibration, etc., would set in within the vehicle frame."

As a result of these and other problems, as well as an initial inability to estimate costs properly in advance on such an unfamiliar project, "to date, The Martin Co. estimates its committed costs to be $47,581,000. This figure has built up from an original estimate of $28,649,000, made in March 1956."

The total estimated cost of the satellite program now stands at $110 million. These are directly chargeable or traceable costs. Of this, the Navy is responsible for supplying all but $13,874,000. The latter amount is being supplied by the Defense Department and National Science Foundation.

Adm. Bennett does not anticipate any further major costly problems, but doesn't rule them out either.

Vanguard Launching Platform Displayed



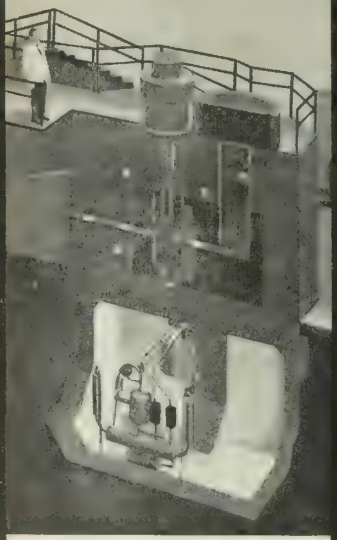
VANGUARD launching and static test platform, manufactured by Loewy-Hydropress, as it awaited shipment to Patrick AFB, where it has been installed for some weeks. (A) Pull-away pickup points on which the rocket rests, (B) the tripod which supports the engine, (C) pipe to carry exhaust to flame deflector, (D) one of four load cells to weigh rocket, fuel, measure thrust and similar functions, and (E) weighing ring for the entire unit.

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Rocket Trends

by Erik Bergaust



WASHINGTON IS WHISPERING ABOUT A POSSIBLE MERGER of the *Atlas* and *Titan* programs. This comes sooner than expected and may be nothing but a rumor. It is conceivable that *Titan* will be taken off the super-priority list. In line with current streamlining and cutbacks, Air Force might want to save some money on expensive overtime work etc.

LOOK TO TWO LARGE CHEMICAL FIRMS to enter the missile picture. One is about to receive a dollar-per-year information contract. (Chose the Air Force because of its open-minded attitude about proprietary rights.) The other company has already spent considerable money in R&D on new solid propellants for industrial uses.

THROTTLEABLE, INFINITE TIME, ON-OFF SOLID PROPELLANT SYSTEM is under test. The system does not employ an auxiliary liquid system for throttling. Standard motor configuration is used for on-off operation. The system is being written into several drawing-board missiles.

JUPITER PROGRAM IS STILL HANGING FIRE. Ford's missile subsidiary is trying to get this IRBM to keep its Chicago (near Midway Airport) plant going. An alternate Ford site may be the Navy reserve engine plant at Romulus, Mich. Meanwhile, Chrysler has lined up 180 potential large vendors for *Jupiter* and is considering a solid-propellant back-up version (to meet increasing solid demands from *Redstone* and to compete with Aerojet's solid *Polaris*).

PHILLIPS PETROLEUM IS REPORTED AS NOT BEING TOO INTERESTED in such high energy oxidants as ammonium perchlorate. Because Phillips' process uses extrusion equipment, grain scale-up is probably now at its peak. From publicly shown pictures, it looks like Phillips is not likely to exceed ¼-million lb/sec for single grains.

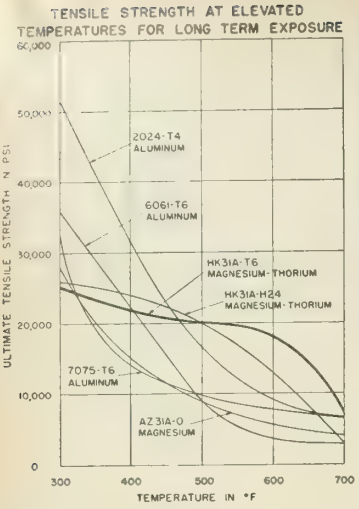
AMERICAN POTASH & CHEMICAL HAS TAKEN ANOTHER STEP nearer getting into the rocket picture. National Northern of West Hanover, Mass. has been acquired by AmPot and will work on squibs, igniters, gas generators, and solid rocket propellants. AmPot is a leading producer of potassium perchlorate and the new lithium oxidants—the nitrate and perchlorate. AmPot also is the nation's only large-scale producer of ammonium perchlorate—which forms the basis for virtually all of our present high-energy composites.

SOVIET MISSILE SPIES IN THE US must have an easy time. All one has to do is drive down US Highway 70 toward Alamogordo, N.M. The *Dart* anti-tank test range is clearly labeled and visible from the road. In addition, all targets are numbered (you can easily determine the distances with your speedometer and take a jim-dandy picture with your camera), so that width of traverse and range can be estimated.

DEATH OF *LOKI* HAS LEFT AMERICA OPEN TO ATTACK by low-flying, enemy cruise missiles. Even effectiveness of *Hawk* (which will not be operational for several years), is questionable against modern low-altitude jet planes or even sonic cruise missiles. A barrage flak rocket is still needed in the defense picture and *Hawk* is designed for a fleet of large bombers and not one single hostile airplane.

REACTION MOTORS INC. HAS DEVELOPED A PACKAGE liquid propellant rocket system. The Navy has expressed considerable interest in the system as a competitor for solid propellant systems. Major feature of the system is its capability of providing a constant total impulse.

DIMETHYL ETHER COMPLEX OF BORON TRIFLUORIDE has been found useful in a process of separating the isotopes of boron. The dimethyl ether complex of boron trifluoride is converted to potassium fluoborate by introducing the complex into an aqueous ethanol solution containing potassium fluoride, expelling ether liberated from the complex and recovering the potassium fluoborate formed.



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Space Medicine

By Hubertus Strughold, MD., PhD.

In a paper given at a symposium on astronautics in Cranfield, England, in July, Dr. Hans G. Clamann from the School of Aviation Medicine at Randolph Air Force Base, Texas, dealt with the importance of metabolic water production in the human body, for a closed cabin system in space flight. In such a system, green algae could be used to convert carbon dioxide and water into oxygen, and into food for the occupants. But over a long period of time, through biological oxidation which reconverts oxygen and food into carbon dioxide and water, an excess of water is continuously produced in the human body and would eventually accumulate in the cabin. This throws cold water on the plans of those space enthusiasts who hope to go into interstellar space, which takes much more than the time necessary to complete this chemical transformation. Thus, in space travel of long duration, the astronaut is faced with a new type of barrier—a "water barrier"—within the closed ecological system of the cabin, which can only be overcome by returning to the paleological stage of an amphibian like the crocodile or by finding some method of dealing with this excess water.

•

Two books have been published in the Soviet Union by Astronomy Professor G. Tikhov under the titles ASTROBIOLOGY and ASTROBOTANY. They deal essentially with the botanical aspect of life on Mars. The greater part of Tikhov's discussion is devoted to the optical properties (reflective and absorptive) of the blue-green areas on Mars, as compared with those of terrestrial plants in the subarctic regions. Studies of this kind are closely related to the work of the Institute of Aerophotography in Leningrad.

•

The books report that a special institute, known as the Department of Astrobotany, has been founded in Alma-Ata, Russia. It also includes a description of an astrobotanical garden, in which hardy cold-resistant plants from the Antarctic which may be possible on Mars, are cultivated.

•

At the School of Aviation Medicine, Maj. Gen. Otis O. Benson, Jr. has expanded the Department of Space Medicine considerably, so that it can cope with all conceivable problems in missile and space operations.

•

Several space medical papers will be presented at the annual Congress of the International Astronautical Federation in Barcelona, Spain, Oct. 7-12. Maj. David G. Simons of Holloman Air Force Base, N. M., will discuss Medical Problems Involved in Sealed Gondolas; Dr. Siegfried J. Gerathewohl will give a paper on producing the Weightless State in Jet Aircraft; and Dr. Ingeborg Schmidt of the University of Indiana at Bloomington, will present research on the Visibility of Artificial Satellites.

•

The writer will attend the Barcelona meeting, representing the Space Medicine Branch of the Aero Medical Association by request of the president, Alfred M. Mayo of the Douglas Aircraft Co., who cannot be present because of other commitments.

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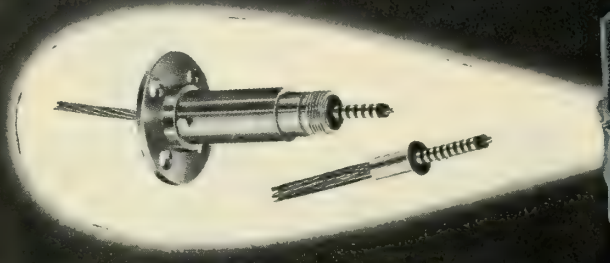
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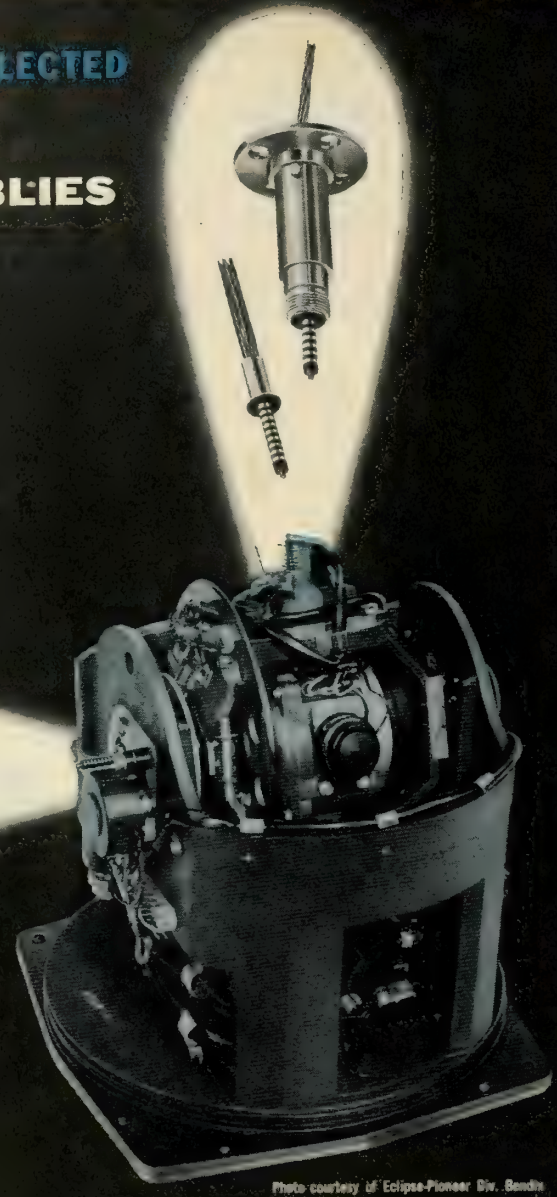
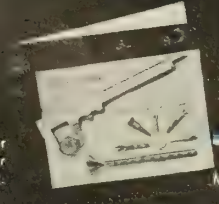


Photo courtesy of Eclipse-Pioneer Div. Bendix

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INTERNATIONAL NEWS

By Anthony Vandyk



Trainer Role for Britain's *Fireflash* Resented

The Fairey Aviation Co. is very bitter at the British administration's relegation of the RAF's first production missile, the *Fireflash,* to a training role. The Weapon Division's Executive Director, C. H. Chichester Smith, says the *Fireflash* WS met all its specification requirements—exceeding several—and points out that it is fully tested, tropicalized, winterized and in production *now*, whereas delivery of the early operational models of the D.H. *Firestreak* will only start eighteen months from now.

Although tailored to the now abandoned Supermarine *Swift,* the *Fireflash* has been successfully adapted as a two-missile installation on the Hawker *Hunter* 6. The beam-riding guidance of the *Fireflash* is an all-weather all-altitude system, in contrast to the infrared homer, which can be foiled by thick cloud.

It seems likely, however, that RAF Air Staff policy has changed on the basis of two factors in beam-riding guidance; (a) human error possibility during period between launch and hit, during which pilot must keep narrow pencil beam aligned on target and (b) the fact that pilot must continue to head toward the possible explosion of a nuclear bomb load.

It is also apparent that the external boost system used to accelerate the *Fireflash* dart must have considerably higher drag than an internal rocket motor.

Description

The *Fireflash* WS consists of a fighter plane fitted with a radar beam, a gunsight, a simple "permission-to-fire" computer, with aircraft-to-missile services and a battery of missiles.

The missile itself is a cruciform unpowered dart which is boosted to maximum speed by two solid-propellant rockets externally mounted on its forward end. During the boost phase the unguided missile is spun by offset venturi nozzles to minimize dispersion due to asymmetric thrust.

At burnout, an explosive separation device throws off the spent rocket cases laterally, leaving the dart to coast supersonically toward the target. The rudders, indexed at 45° to the wings, unlock at separation and the missile is roll stabilized by aileron-type (differential) rudder action to a datum established at launch.

As soon as roll error is reduced to specified limits, guidance commands are switched to the control blocks. The missile's position relative to the axis of the radar beam, measurable in polar co-ordinates, is interpreted as Cartesian linear errors resolved in the two control planes, pitch and yaw.

The pneumatic actuator, served by electro-pneumatic relay valves, applies rudder deflection which reduces linear errors and returns the missile toward the beam-axis. During this gathering phase, clamping diodes limit maximum lateral acceleration. The missile then rides along the beam axis, following any beam motion which may occur.

Thus accuracy of *Fireflash* is dependent upon the accuracy with which the beam is laid on the target. In daylight the fighter pilot simply tracks the target by keeping the image at the center of his gunsight graticule. The radar beam axis is accurately harmonized relative to the gunsight axis, so that the only significant guidance error introduced is that due to the aim-wander of the pilot airplane combination in tracking the target.

Development trials were carried out by Fairey on suitably modified

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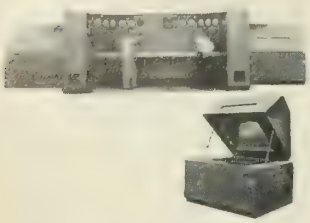
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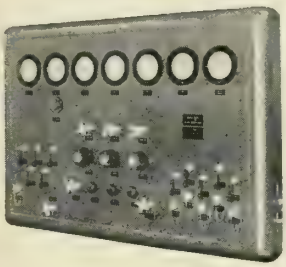
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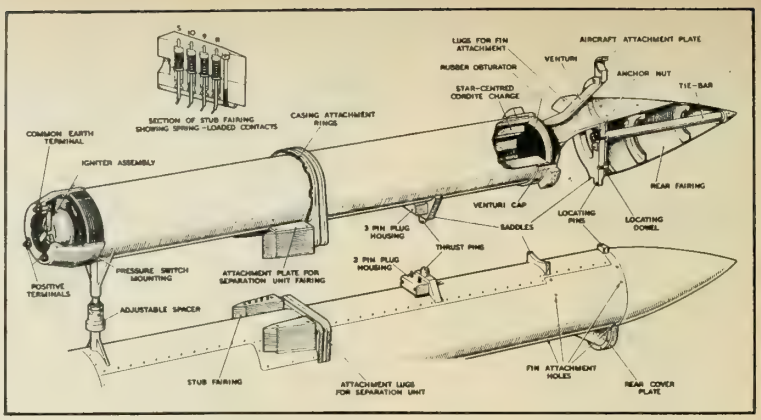
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Cut-away view of FIREFLASH booster rocket and attachment fittings.

Meteor 7 and *Meteor* NF 11. Successful beam-riding has also been demonstrated from a two-weapon installation in a *Hunter*. A third installation, in a RAF squadron of *Swift* F 7 fighters, is currently operating as a missile training unit. Installations in other planes are practicable and simple.

Construction

The *Fireflash* breaks down conveniently for ground handling into the rear cylindrical portion of the dart, which contains all the control, guidance and power supply equipment, mounting wings and rudders and an explosive assembly comprising the warhead and its fuse, the two boosters and their separation gear. This assembly is simply attached to the main body of the dart, after it has been fully pre-flight tested on a Fairey O.A.T.S. (Operational Airfield Test Set).

Structurally, the rear body of the dart is a magnesium-zirconium alloy extruded and forged tube, into which slides a two-rail chassis carrying the internal equipment. The wings and rudders are aluminum alloy precision forgings machined only over their attachment bosses.

The boosts are attached to each other by a U-shaped separation unit and fittings on the motors mate with holes in the warhead case. The fuse is attached to the warhead, and a spacer device forward of the fuse tip pre-tensions the assembly to make it adequately rigid.

The separation gear comprises a twin piston-cylinder breech block containing 0.06 lb of cordite. The pistons, attached to one motor, are held by shear pins in the cylinders attached to the other motor. A single igniter in the base of the unit flashes to the two separate charges in the two cylinders.

A pressure switch, which arms on build-up of pressure in the boost rocket case and fires when the pressure subsequently falls to 250 lbs/sq in., is located in the nose of each rocket. These are series-connected, so that when both boosts are all-burnt, a firing pulse is passed to the igniter.

The pressure in the cylinders builds up until the shear pins fail and the boosts then separate relative to each other and to the dart. The boosts are fitted with stabilizing fins to prevent toppling after separation, which could cause deceleration fast enough to endanger the firing airplane.

Control and guidance components mounted on the chassis, from front to rear, list as follows:

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- Air-blown gyro assembly: roll displacement gyro, two rate gyros for the two control planes. These are con-



A FIREFLASH is examined after it has been exposed to a simulated dust-and-sand storm for an hour.

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Many years of research and testing went into the development of the unique and patented Fluoroflex-T tube. The 3000 psi hose assemblies emphasize anew the conservative policy of Resistoflex in presenting a product. *Long term* testing and *field service* were essential phases in the development. Send for data.

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tinuously blown while the missile is attached to the airplane, but coast during missile flight—the rate gyros have speed monitors.

- "Receiver": electronic component blocks predominantly interpreting received guidance signals, plus control system electronic components.
- Electric power supply assembly.
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Russians Design Burner Devices for Rock Boring

Russia claims to be pioneering in the development of non-military uses for "rocket" engines.

Scientists at Moscow's Bauman Institute—an aviation research center—have designed burner devices for boring granite and other hard rock with a gaseous stream obtained by combustion of kerosene. Sections of rock at which the incandescent streams of gas are directed are heated rapidly and unevenly. This causes the rock to break up instantly into scales that are blown out of the bore hole.

According to the Russians, this method allows holes of various diameters to be bored in the hardest rock "many times faster" than by mechanical methods. By reducing the exhaust velocity of the gas, it is possible to make a pocket for explosives.

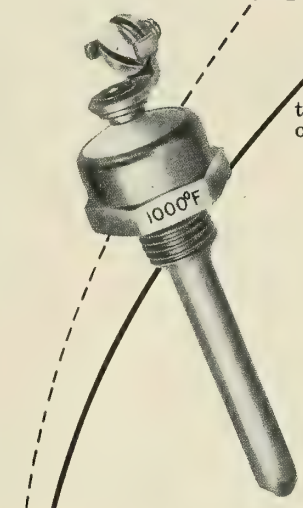
Soviet reports say that this form of heat boring is cheaper than any other process and is being introduced at quarries and pits. Portable "rocket borers" are planned for mineral prospectors.

Red Meteorite Probe In Progress for IGY

The Soviets report that their IGY study of meteorites is being concentrated in four observatories: at Kharkov in the Ukraine, Kazan on the Volga, Tomsk in Siberia, and Stalinabad in Tadjikistan (Central Asia). Accounts of this work are being made public by Professor V. V. Fedynsky.

At Stalinabad, Pulat Babajanov, a young Tajik scientist, is in charge of meteorite work. He guides the "meteorite patrol," as the Russians call their meteorite-photographing camera. As the result of the camera's continuous performance, the Stalinabad observatory now owns hundreds of photographs of meteorites in flight. With the aid of these photos, Babajanov and his associates are calculating the meteorites' trajectories and speed.

New CPI thermal switch is *Light and Lively*

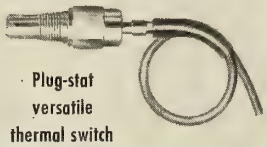


This new lightweight (weighs less than one ounce) thermal switch features an operating differential of plus or minus only one degree with extremely fast response.

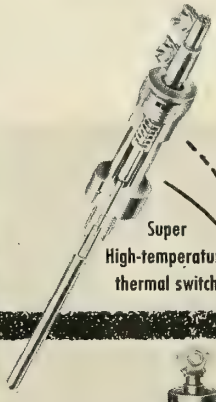
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This is only one of the dozens of instances in the development of missiles and rockets where getting a design off the board and into the air depended on finding materials with unusual properties. Kennametal has been usually successful in filling these needs, providing not only corrosion resistance, but heat and abrasion resistance, also.

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World Astronautics



By Frederick C. Durant III

The orbits planned for the Russian IGY satellite vehicles have been reported to be "at a small angle to the meridian." Reliable information just received indicates that the orbit will be about 60°. The U.S. orbit selected will be about 35°. This choice by the Russians will permit viewing of their satellites by a much wider portion of the earth than those of the U.S. Areas which will be able to view the U.S.S.R. satellites include Great Britain and all of Europe from Madrid to Oslo, the northern half of the U.S. and most of the U.S.S.R.

•

Astronautical personalities from all over: Photon rocket pioneer Dr. Eugen Sänger, Director of the Forschungsinstitut für Physik der Strahlantriebe e.V. Stuttgart, has been hospitalized for a cardiac condition. First President of the International Astronautical Federation and a rocket scientist for more than 20 years, Dr. Sänger's many friends wish him a speedy recovery.

Len Carter, Secretary of The British Interplanetary Society, and editor of the excellent JOURNAL OF THE BRITISH INTERPLANETARY SOCIETY for more than 10 years, is stepping down from his post because of press of other Society duties. Carter rates a real expression of thanks.

Two recent birthdays are noted in Germany. Dipl. Ing. Leo Zanssen, former Major General at Peenemünde, celebrated his 60th. WELTRAUMFAHRT editor and ex-BMW rocket engineer and author, Dipl. Ing. Heinz Gartmann celebrated his 40th. British physicist and top science fiction writer Arthur C. Clarke writes from Colombo, Ceylon, where he has been aqua-lunging, that he'll attend the IAF Congress at Barcelona in October. His latest work, THE MAKING OF A MOON (Harpers), has just been released. Former German rocket expert Dipl. Ing. Rolf Engel, Technical Director of C.E.R.V.A., Heliopolis, for the past five years, has left Egypt with combustion specialist Dr. U. T. Bödewadt. Engel is now in Rome acting as a consultant to the Italian Ministry of Defense.

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From Japan comes word that Mitsubishi Shipbuilding Co. is concentrating on liquid propellant research for rockets. Japan Oil Co., Asahi Trans. Co. and Japan Carlit Co. are working on solid propellants.

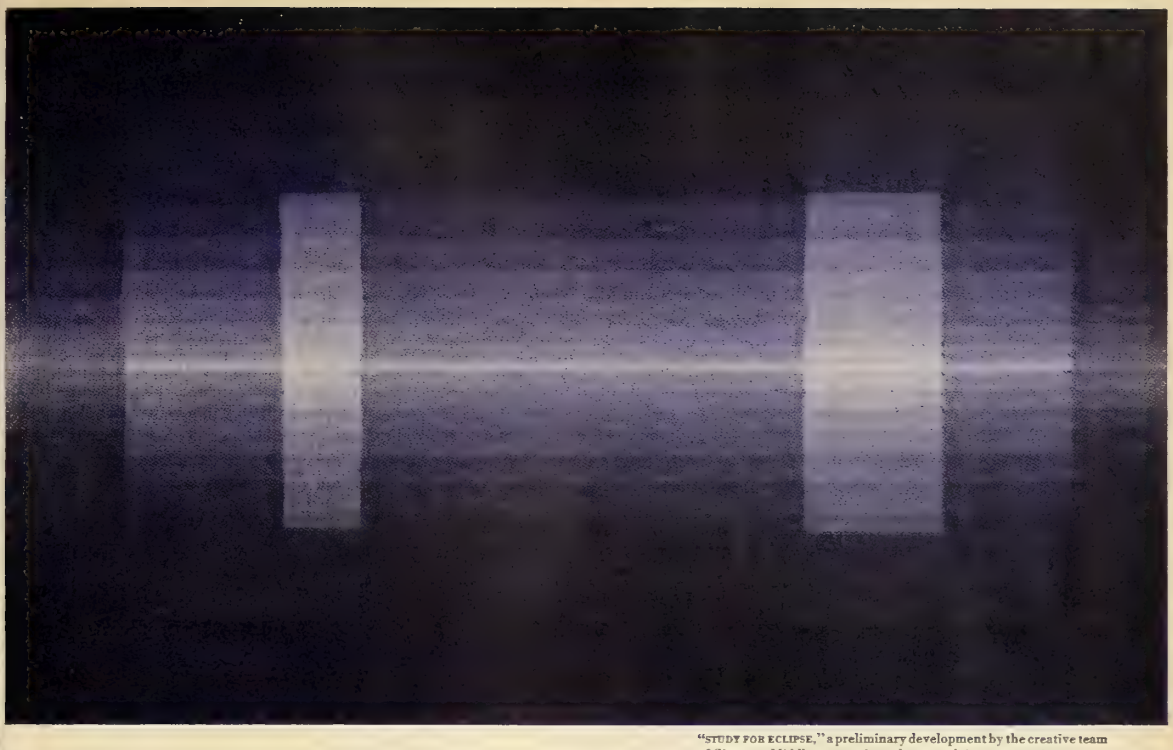
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The West German government has purchased 1000 jeep-launched SS-10 anti-tank missiles from France. The similar anti-tank rocket development of Bölkow Luftfahrtenwicklungen, Stuttgart, is in the latter stages of development.

Rocket motor tests of increasing size at the Deutschen Arbeitsgemeinschaft für Raketentechnik, Bremen, had to be shut down recently because of "noise and danger" at the local airfield. This is an old story to amateur rocketeers. New test facilities have been completed near Oldenburg, about 30 miles west. Tests on the oil-spray rocket (m/r April, p. 88) will be conducted on the nearby Zwischenahner Meer during the DAFRA meeting this month.

•

Artemis Press, London, has recently published the fascinating SPACE ENCYCLOPEDIA. Eight well known authorities (including NRL's Homer Newell and space medicine man Dr. Hubertus Strughold) have written an excellent reference work. Details of guided missiles and upper atmosphere research are uniquely combined with a survey of all branches of astronomy.



"STUDY FOR ECLIPSE," a preliminary development by the creative team of Simpson-Middleman, artists whose work is a penetrating expression of the forces and phenomena of the natural sciences. This painting is one of the steps—ground structure—in which the ultimate action will take place. Courtesy of John Heller Gallery, Inc.

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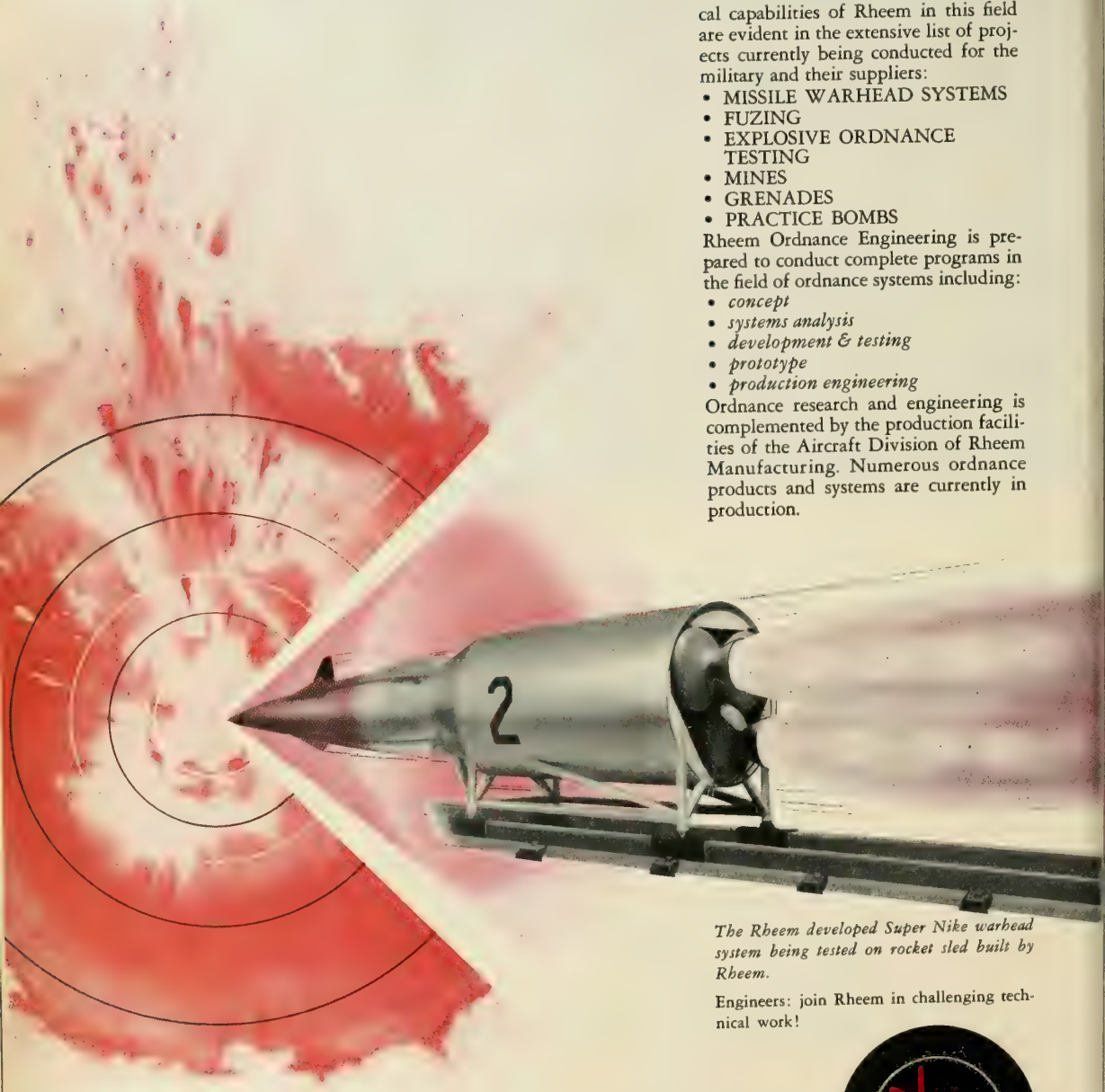
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Behind the Curtain

By Dr. Albert Parry

"Our bombs and rockets are no worse than yours," said Nikita Khrushchev to a group of American tourists in the Kremlin on July 24.

Note that Khrushchev did not claim their rockets are superior to ours. Could be that he didn't then want to alarm the U.S. into a redoubled effort to catch up with the Soviet Union. Only a week before, an alarming report was published in the U.S. press that the Soviets had been firing intermediate-range ballistic missiles for at least 18 months at a rate of more than five a month—this against our successful testing of just one non-operational IRBM, the Army's *Jupiter*.

Soviet policy is highly opportunist, however, attempting to soothe or panic the world according to the political dictates of the moment. Thus, the recent ICBM announcement comes at a time when Russia wants no interference from the West in its efforts to grab off Syria; just three weeks prior to the opening of United Nations debate on Hungary; and near the end of deadlocked London disarmament talks.

Red policy is also contradictory sometimes, as witness the peace-loving protestations of Russian scientists Anatoly Blagonravov and Yu. Khlebtsevich on "soon-to-be-fired" Red moon rockets.

Contrary to certain American fears, they said in TRUD, the Soviets do not plan to appropriate the moon. Says Khlebtsevich, Chairman of Moscow's Scientific-Technical Committee on Radio-Tele-Guidance in Astronautics: "The aim of the Soviet scientists is not at all to establish military bases on the moon so as to threaten the U.S. from there. Our efforts in astronautics are to penetrate the secrets of cosmic space the soonest; to comprehend the measureless universe the deepest."

According to Professor A. A. Blagonravov, head of the Technical Sciences Division of the Soviet Academy of Sciences, the construction of war bases on the moon "is an absurdity to any sober-thinking military expert in any country." The Soviets feel, declares Blagonravov, that "the unfurling of any national flag on the moon should not at all be the basic goal" of the world's astronauts.

To prove the peacefulness of the Red rocket-to-the-moon plans, both Moscow scientists suggest that Americans join with the Soviets in all research and rocket-building, not only with our brains but also with our dollars.

The economy-minded among us are tempted by Khlebtsevich when he insists that the Russian blueprints of such rockets and their flights "will be far less expensive than American projects" of similar enterprise. Let's start right away, Blagonravov urges. "We would be glad to inaugurate a steady, firm contact with the scientists of the U.S. working in astronautics; also with American interplanetary rocket societies."

•

The official Soviet telegraphic agency TASS gives prominence to unofficial information from Bonn that West Germany and Great Britain have prepared a "secret" plan of collaboration in developing and producing certain "modern types of weapons," including "guided missiles and rockets with a distant radius of action."

The plan, says TASS, was slated for early discussion in London by "military experts of both nations." The report adds that the West German government has a similar cooperative plan with France.

With this report as Moscow's excuse, we may now expect more of a Red admission that missile-and-rocket work is being carried on by the Soviets in East Germany.

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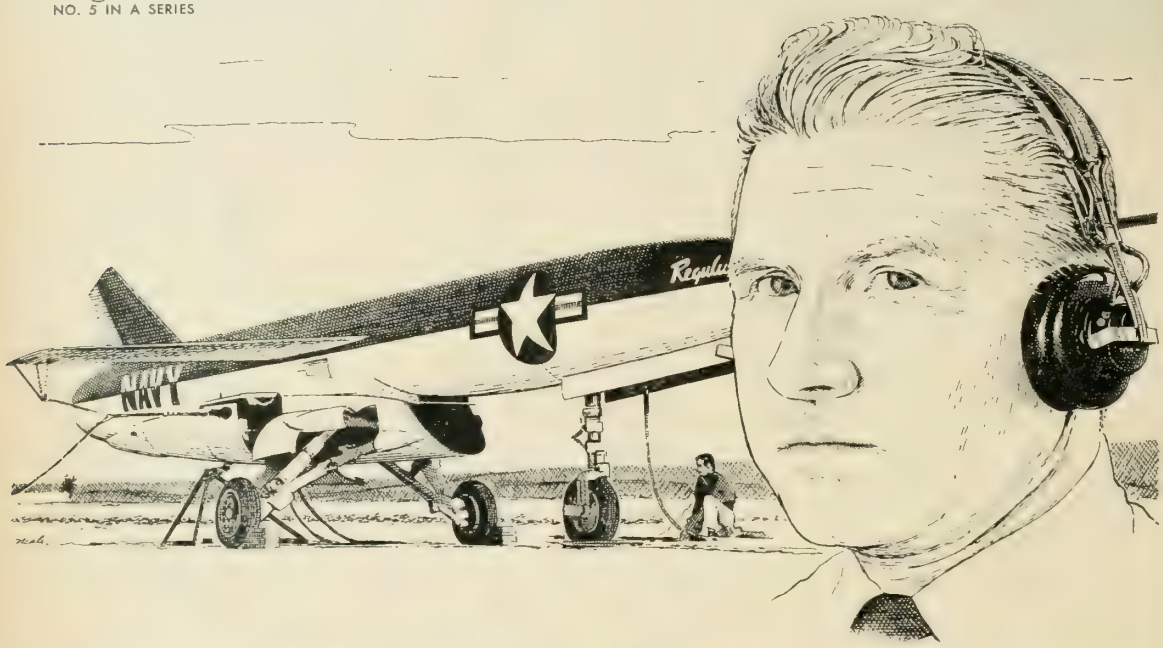


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Why the Missile Engineer Never Missed Mail Call

Vought's Regulus II missile took shape just a short walk from the desks of its developers. Engineers handled the new hardware and monitored tests in person — literally flying the big missile on the ground at Dallas. It was a convenient arrangement while it lasted.

Then a big USAF Globemaster landed and taxied to Vought's Experimental Hangar. The missile was winched aboard and airlifted to a desert site for flight tests. By nightfall there was a 1,000-mile rift between Regulus II and home base.

Joe Boston was ready to step into this gap. As Project Assistant for Field Liaison, he'd already equipped Vought's desert crew for extensive flight tests. Now he'd make sure that test data and hardware flowed uninterrupted from the desert to Vought. High-speed feedback of facts on one flight could influence the success of the next.

Mail from the desert poured in to Joe at Vought. From project men at the flight test site came parts for immediate rework and return. From the flight test crew's mobile ground station came rolls of telemetered brush records. From the recoverable Regulus itself, came packets of oscillograph data. And from Field Service — for repair or replacement — an occasional wrench or relay.

Joe served as clearing house and consultant. Flight data was reduced and released to design and support groups. It revealed not only missile performance, but the temperatures and pressures of a strange new environment. When data pointed toward design changes, Joe's time and cost estimates helped specialists reach decisions.

Thanks to Vought's fast overland relay of hardware and data, the records of one flight were decoded and digested in time to improve the next hop. Dividends in performance and reliability were obvious after six flights had been logged by Regulus II.

All six had been flown by one vehicle.

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CHANCE VOUGHT AIRCRAFT
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Washington Spotlight

By Henry T. Simmons

Appointment of the Holaday-Schriever-Medaris committee to determine the final configuration of the Air Force's 1,500-mile IRBM was calculated to raise the decision from an interservice to a "national" level, according to one Pentagon insider. He believes it may be the first of a series of high-level actions aimed at eliminating sources of interservice wrangling over missile assignments. Though no decision has been made at this writing, the odds apparently favor selection of the *Thor* engine-airframe combination, with the decision as to guidance and control left open until a later date.

•

North American is scheduled to fire four more XSM-64 *Navaho* test vehicles during the remainder of the research program authorized by the Air Force. Landing gear will be removed and no attempt will be made to recover the birds. Ironically, NAA's launching attempt last month worked perfectly, following four successive failures. The test vehicle reached design speed and altitude and covered a distance of 350 miles. The success came almost exactly one month after cancellation of the project.

•

The Air Force's new "multiple-source" development policy will have a greater impact on the missile industry than any other group of defense contractors. As outlined by Assistant Air Force Secretary Richard Horner (R&D), the policy calls for joint development undertakings by two or more companies in order to restrict outlays for new facilities. This means a company proposing a technically superior solution cannot expect USAF facilities support as in the past, but will have to enter into licensing arrangements with another firm which does have the necessary facilities. "We recognize our deficiencies in officiating at such a marriage," Horner said, but declared there is "increasing evidence" that the aeronautical industry will accept the new arrangements.

•

Most disconcerting exhibit on display at the D.C. Armory during last month's Air Force Association convention here dealt with aviation medicine. It showed a cutaway section of a rocket nose cone with chambers containing models of two disconsolate monkeys. The simians appeared to be making unearthly cries, but it was later discovered that the noise came from a squeaking bearing in an exhibit in the next booth.

•

Rocket propulsion appears to be losing its monopoly in the USAF's arsenal of airborne missile systems. The new WS-131B air-to-surface missile, awarded to North American, will use turbojet propulsion. Fairchild J83, General Electric J85 and other new engines have been suggested. USAF weapon system planners believe that turbojet propulsion offers more room for growth in certain missiles than rocket power.

•

A high-level civilian committee may be created in the Pentagon in the near future to coordinate the release of missile technical data to NATO countries interested in building U.S. missiles under license. The committee would presumably control the types of missiles cleared for use by the nation's foreign allies. The Navy's *Sidewinder* has been mentioned as one possibility for the NATO countries, and there have been suggestions that Britain will build the Air Force's intermediate-range ballistic missile when it is fully developed.

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MINNEAPOLIS **Honeywell** H HONEYWELL

BOSTON DIVISION

missiles and rockets

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MAGAZINE OF WORLD ASTRONAUTICS

m/r exclusive:

Report on Our Booming Missile Communities

a special service for m/r readers

During the last ten years a fabulous chapter in the book of American industrial expansion has been written. This is the story of our booming missile and rocket communities, the mushrooming test, research and development centers in the South, the West and the East. This is the story of the migration of scientists, engineers and military men to arsenals and bases that are sometimes hidden in a desert or on a tropical island. Sometimes they have sprung up out of nowhere: sometimes old war bases have been reactivated and small towns and communities have been completely re-erected and re-organized to keep up with the Klondike-type economic boom that has always followed.

The missile industry is coming of age. It appears to be separating itself from the aircraft industry and is about to outgrow it. In this respect, names like Patrick, White Sands, Redstone, Point Mugu, Palo Alto have become significant. In a period when we witness cutbacks in manpower and arms, when our aircraft and navel ship-building programs are being streamlined, missiles are zooming ahead. Because missiles form the backbone of tomorrow's defense, the missile industrial boom will continue. It probably will continue indefinitely, for it is our key to space flight and offers limitless possibilities.

A phenomenon of the missile and rocket industrial expansion in progress throughout the U.S. is the trend of many national nonmissile companies to establish plants in the new missile communities. Private contractors paving the way for small and large businesses, homes, schools, churches, follow in the wake of Army and Air Force bulldozers.

MISSILES & ROCKETS has followed this industrial boom closely, its editors having traveled thousands of miles to compile facts and figures on every major missile industrial expansion area, such as the areas around Patrick, Huntsville and others.

As a special service to our readers who might be considering moving across the country to any one of these missile Klondike areas, m/r introduces in this issue (next page) the first in a series of *complete analyses* of our missile communities. Our editors selected Patrick AFB and Cape Canaveral Auxiliary AFB as the first of this series because of their current importance as test sites for all three services and because the Air Force has just let new housing contracts in the area representing many millions of dollars.



U.S. Department of Commerce figures show that in the 10 years 1946-55 Florida led the seven Southeastern states in the amounts spent for new industries, with a jump of 110% from more than $50 million to upward of $105 million. Georgia came next with almost 100%, followed by Tennessee, 82%; Mississippi 72% and Alabama, 15.3%. The Florida Development Commission, in a recent report, lists 163 industries which, during the first half of the year, announced plans for new plants or expansion of existing plants, and this list does not include some of the more recent acquisitions such as Pratt & Whitney Aircraft Division of United Aircraft, The Martin Co., and others. Projected new plants and expansions run to $200 million or more.

In forthcoming issues m/r will present roundups on other missile communities. This *special service* is in accordance with m/r's editorial policy and is possible because m/r editors make it a point to travel extensively and get on-the-spot news and first-hand reports from the experts in the field.

The editors of m/r express their thanks to the U.S. Air Force and the Florida Chamber of Commerce, without whose assistance, this first roundup on Patrick AFB would not have been possible.

The Editors



m/r exclusive

PATRICK AIR FORCE BASE
today and tomorrow

By Erik Bergaust

PATRICK AFB—Stretching along more than 4 miles of highway A1A in Florida, Patrick Air Force Base occupies the beautiful land area between the Atlantic Ocean and the Banana River. The long, narrow installation is one of 13 Air Force missile test center activities and serves as headquarters for the group.

Originally built as the Banana River Naval Air Station, the post was deactivated after World War II, turned over to the Air Force in 1949, and renamed after Major General Mason Patrick, first chief of Army Air Services. The base covers 1822 acres and houses much of the administrative and logistical functions of the test center. Two runways are in operation at the field, one of 4000 feet and one of 10,000 feet.

Organization

Maj. Gen. Donald N. Yates, who probably knows more about missiles than any other military man in the country, assumed command of AFMTC in July 1954, after four years of research and development duty at Air Force headquarters. General Yates, a rated command pilot, has won the Distinguished Service Medal, Legion of Merit, and the Air Medal. His foreign decorations include the Degree of Chevalier in the French National Order of the Legion of Honor, the French Croix de guerre with Palm, the Degree of Honorary Officer in the Most Excellent Order in the British Empire, and the Ordem Militar de Christo of Portugal.

The General is a former president of the American Meteorological Society and a member of the Institute of Aeronautical Sciences and the American Rocket Society. He and his wife live on the base.

The deputy chief of staff for operations directs the center's programming. He makes policy, and provides program guidance and information for budget preparation. He is the watch dog of the center's activities when it comes to reprogramming and establishment of priorities. He decides what should be done and when. He also sets up liaison with foreign governments on down-range matters, directs staff intelligence activities and conducts the manpower and organizational programs.

The deputy commander for tests has charge of guided missile test planning. He controls engineering evaluation, data reduction, and photo lab facilities through the test engineering directorate. Official contact with the missile contractors is maintained through the project offices of the deputy commander for tests. He keeps in close touch with testing agencies' activities while at AFMTC.



Major General Donald Yates, USAF, Patrick AFB, Commander.

The deputy commander for range directs use of the AFMTC range. He makes policy on its use and on safety and sees that it is carried out. He assists the commander in supervising the activities of the range contractor and supervises the directorate of range operations and range development.

The deputy commander for support acts for the commander in administrative and logistical support operations of AFMTC. He commands the air base group and is designated base commander.

The director of range operations heads up communications, instrumentation, aircraft and range facilities in direct support of tests.

The director of range development controls all nonstandard range communications and instrumentation systems development for AFMTC. He supports and watches over the range contractor's development efforts.

The commanding officer of the 6550th Air Base Group is head man at Patrick Air Force Base and provides staff, administrative and logistical support to the command.

Missiles received at the center are handled by the 6555th Guided Missiles Squadron, which inspects, assembles and launches missiles. It also introduces military cadres to new guided missile programs and implements and evaluates firing procedures.

Logistical support for down-range stations and aircraft and crew support for the testing program is provided by the 6550th Operations Squadron.

Actual operation and management

of the various stations along the test range, including the launching site at busy Cape Canaveral, are the responsibility of Pan American World Airways and RCA. They maintain facilities and equipment and plan range operations to support missile test data. Various missile contractors have set up field stations for missile testing.

Other operating units at the base include Detachment 11, 4th Weather Group, responsible for forecasting and observing weather conditions in connection with missile launchings; the Patrick AFB detachment of the 7th district, Office of Special Investigations; the 2026 Airways and Air Communications Squadron; the Army Ballistic Missile Agency; and the Naval Ordnance Test Unit.

Down-Range Station

The AFMTC neither builds missiles nor fires armed missiles. It acts as a test facility and evaluation center for missiles of the three services. AFMTC provides the test range, assures the safety of the range area, and gathers information on missiles in flight. It then analyzes the data and determines whether missiles meet established requirements.

For several years, the AFMTC has been firing missiles from Cape Canaveral to the first island station on Grand Bahama, some 180 miles to the southeast. At about the center of the island is the Auxiliary Air Force Base, containing radio facilities, range clearance, inflight safety, weather reporting, telemetry reception, and radar and optical tracking equipment. Beyond Grand Bahama, other island stations are Eleuthera, San Salvador, Mayaquana, Grand Turk, Dominican Republic, Puerto Rico, St. Lucia, Fernando de Noronha and Ascension Island. Each station has both a military base commander and a civilian commander.

The Cape

Cape Canaveral Auxiliary Air Force Base consists of 12,160 acres of government-owned land, 18 miles north of Patrick AFB. The area is cut off from the mainland by the Banana River and until recently, its only landmark was a lighthouse. Today, the site is as busy as any big air base.

Actual launching of missiles takes place at the Cape. The first launching from Canaveral was that of a V-2 on July 24, 1950. The operation of Cape Canaveral became the responsibility of PAA in March 1954.

Facilities at the Cape include launching areas with blockhouses, radio transmitter and receiver sites, telemetry receiver sites, radar, missile assembly buildings, guidance laboratories, LOX plant, photo-theodolite and camera sites, power supply buildings, motor pool, dining hall and fire station.

All activities at the Cape are coordinated at the central control building, three miles from the launching sites. It houses the range clearing and in-flight safety sections and the contacting center for all down-range stations. While in-flight safety functions are located at the Cape, this function may be transferred to any down-range station. There is a skid strip on the base for the recovery of missiles when possible. Normally, the missiles are impacted into the sea.

A submarine cable connects Cape Canaveral to the down-range stations as far as Puerto Rico and serves as a key factor in transmission of technical data during missile tests.

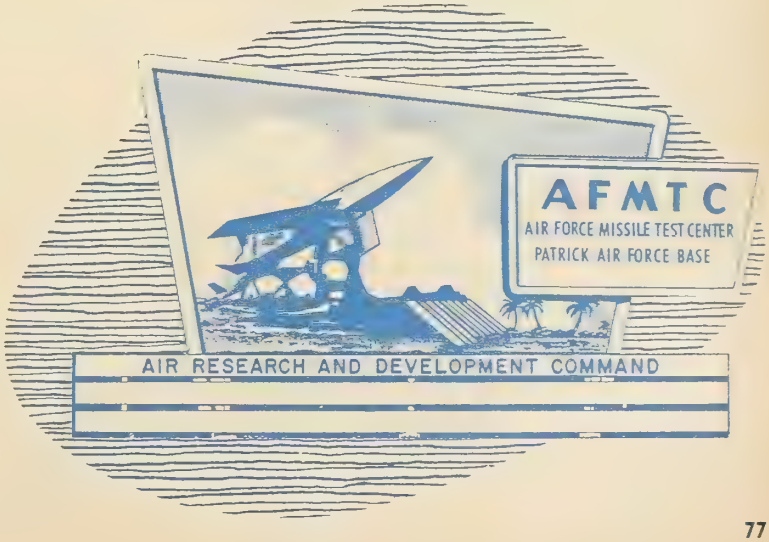
Housing

In addition to a few government quarters, there are 680 Wherry housing units (built and rented by a private concern) on the base. In the south Wherry area is a new primary school for the first through sixth grade for children whose parents live on the base. Congress has already approved 999 Capehart housing units for the base, and the Air Force has requested an additional 1000 units, bringing the total to 2679 housing units.

Construction of the 999 authorized units is expected to start soon. Bids have been submitted by various contractors and details of the arrangements are being worked out. In requesting more housing, the Air Force certified to the Federal Housing Administration that the base would be in operation for a longer period of time than that required for amortization of loans made in connection for the Wherry housing project. This means that the base will have to be utilized for at least the next 20 years. One Air Force Colonel put it this way, "The base is here to stay."

Air Force officials expect that about 150 houses will be ready within six months. These will be occupied as they become available. An additional 400 are scheduled for completion within a year, and the entire number within 18 months. The proposed housing area of about 300 acres will be connected to the base by an access road. Included in the plans, are a commissary, a chapel, and several recreation areas. The entire project is under AF supervision.

The individual houses will be constructed of concrete block and brick masonry, with terrazo floors and plastered walls and ceilings. Heating and air conditioning will be included in all





RANGE: The Air Force Missile Test Center operates the Florida Missile Test Range, the world's longest range for testing guided missiles. Bases are in operation or under construction along 5,000 miles of range from Cape Canaveral, Florida, southeast over the Atlantic to Ascension Island. Picket ships gather data between St. Lucia and Ascension.

units and each will have a garage. Many of the houses, and perhaps all, will have screened terraces.

The Capehart housing units will be for military personnel, who will be charged their quarters' allowance for use of the house with all utilities furnished. The housing quarters are being constructed under the government's policy of aiding free enterprise by contracting civilian companies for construction whenever possible.

Approval and guarantee of the construction mortgages will be processed through FHA channels from the Tampa field office. The contractor for the Capehart units will finance the project, while the AF will be tenants, making monthly payments until the mortgages are paid. The Air Force will then be sole owner of the housing.

In addition to the Capehart projects, the AF will buy the 680 Wherry units from their civilian owner. Patrick's Installations Office will begin a renovation process on the Wherry units and they will become quarters for military and civilian personnel at AFMTC.

Except during the peak of the winter season, small furnished apartments and rooms are in fair supply. The bulk of sale housing is newly built and attractively planned, mostly concrete block stuccoed, modern ranch-type units. Of the many housing projects under way in the area, most contain their own shopping centers. A list of real estate firms active in the area is available from the local chamber of commerce.

Present employment at AFMTC is about 15,500, compared to 1955's 8500 and 1950's 1500. By the end of 1958, the AF expects to have more than 18,000 employed at the base.

Of the 18 contractors at the base, about 12 are considered "major". The range contractors are Pan American World Airways and Radio Corporation of America. Others include Boeing Convair, Douglas, General Electric, Martin, Lockheed, North American, Northrop, and Ramo-Wooldridge.

Over 9500 of the base personnel are contractor personnel. Almost half of the total expenditures at the base in 1956 was spent in Florida, with 33 per cent being spent in surrounding Brevard County. The present AF payroll at Patrick amounts to about $6 million monthly.

The 225 separate parcels of real estate along the test range are the responsibility of the Air Force. Extending from the Florida coast to Ascension Island in the south Atlantic, the easements and right-of-way making up the 5000-mile range have been valued at a net worth of $335 million.

Schools

Public schools in surrounding Brevard County are operated on a full nine-month term. Approximately 5000 children from the Cocoa area are enrolled in eight local schools, and school bus service is available in all outlying areas. No tuition and all text-books are free. However, automobile owners are required to purchase Florida license plates if their children are enrolled in the state's schools.

The high school is fully accredited and offers courses in commerce, vocational home economics and industrial arts in addition to the regular academic courses. The county adult education program is one of the most progressive in the state and offers a variety of evening courses. It's enrollment is the fourth largest in the state.

Churches

The twenty-two churches in the Greater Cocoa area represent many denominations. Assembly of God, Baptist, Catholic, Christian, Christian Science, Church of Christ, Church of God, Episcopal, Lutheran, Methodist, Presbyterian and Seventh Day Adventist. Services for Jewish, Protestant and Catholic faiths are held at Patrick AFB. A complete list of churches is available from the local chamber of commerce.

Climate

Florida weather lives up to its billing: clear sunny days and pleasant cool nights. The area has never experienced sustained winds of hurricane force. A constant breeze blows from either the Banana or Indian rivers or the ocean. Elevation ranges from sea level to 81 feet. Almost all types of soil are found in the area although sandy loam is predominant and is suitable for the growing of many varieties of fruits and vegetables.

Here are some attractive figures from the U.S. Weather Bureau:

	Normal Temperature	Normal Rainfall
January	62.2	2.72
February	63.7	2.83
March	67.0	2.81
April	71.4	2.25
May	76.2	4.00
June	79.5	6.20
July	81.2	6.37
August	81.5	5.43
September	80.0	7.30
October	75.5	6.59
November	68.4	2.17
December	63.2	2.52

Health

Wuesthoff Memorial Hospital, a nonprofit community hospital located at Rockledge, is a modern, well-equipped fifty-bed hospital. In addition to facilities at Patrick AFB for base personnel, the Cocoa area has fourteen medical doctors, two chiropractors, four dentists, two optometrists, and one chiropodist. The Brevard County Health Department has offices in Cocoa with a resident medical doctor and a staff of nurses. A doctor is on call at the hospital at all times for emergencies, and a list of local doctors available for emergency calls, may be obtained from the chamber of commerce.

Water Supply

Water for Cocoa and Rockledge is secured from a clear lake through

waterworks owned by the city of Cocoa. Water is filtered, fluoridated and chlorinated. Capacity of the $485,000 plant is 2,115,000 gallons per day. Average consumption is 900,000 gallons per day. Water rates for Cocoa are: 5000 gallons or less, $2.50; over 5000 to 10,000 @ 30¢ per thousand; over 15,000 to 20,000 @ 25¢ per thousand; over 25,000 @ 20¢ per thousand. Water is inclined to be hard, but water softener is available.

Electric Power

The area around Patrick AFB and Cape Canaveral is served by the Florida Power and Light Co., which owns and operates the generating and distribution systems. The minimum electric bill in incorporated areas is $1.25, and in unincorporated areas, $1.50. Rates scale down to 1½¢ per kilowatt hour. Rate sheets will be furnished by the local office. The electric power is adequate and dependable.

Economy

Extensive citrus groves produce famous Indian River premium fruit, and the Cocoa-Rockledge area is the largest shipper of citrus gift packages in Florida. There are six commercial packing houses that pack carloads of fruit daily during the fruit season.

Vegetables are grown during the fall and spring and such sub-tropical fruits as mangoes, avocadoes, guavas, papayas, and bananas grow well here. Production of these on a commercial basis is increasing.

There is extensive beef cattle farming in the area and thousands of acres of land have been converted to improved pasture. Other agricultural activities include forestry, poultry, dairying, commercial gladiolus and gladiolus bulb raising, honey production, etc.

There is an abundance of sea food in commercial quantities, obtained from both the ocean and two nearby rivers. Fishing is a major industry, primarily shrimp.

Fishing and Hunting

Fishing is probably the most popular sport of the area. The ocean, salt waterways, rivers and fresh water lakes in the vicinity attract fishermen from all over the country. Fishing licenses are not required for fishing in salt water. This includes the ocean, Banana River, Indian River, and Sykes Creek. The best fishing spots in the rivers are from banks or bridges and the most popular equipment is casting rod with level-winding reel or fly rod. Fish caught in the rivers are usually large.

Trout, drum, bass and snook are found in great quantities in the local rivers, while the ocean surf yields channel bass, blue fish, snook, flounder, weakfish (salt-water trout), pompano, drum, whiting, tarpon, sea bream, triple tail, sheephead and mangrove snapper.

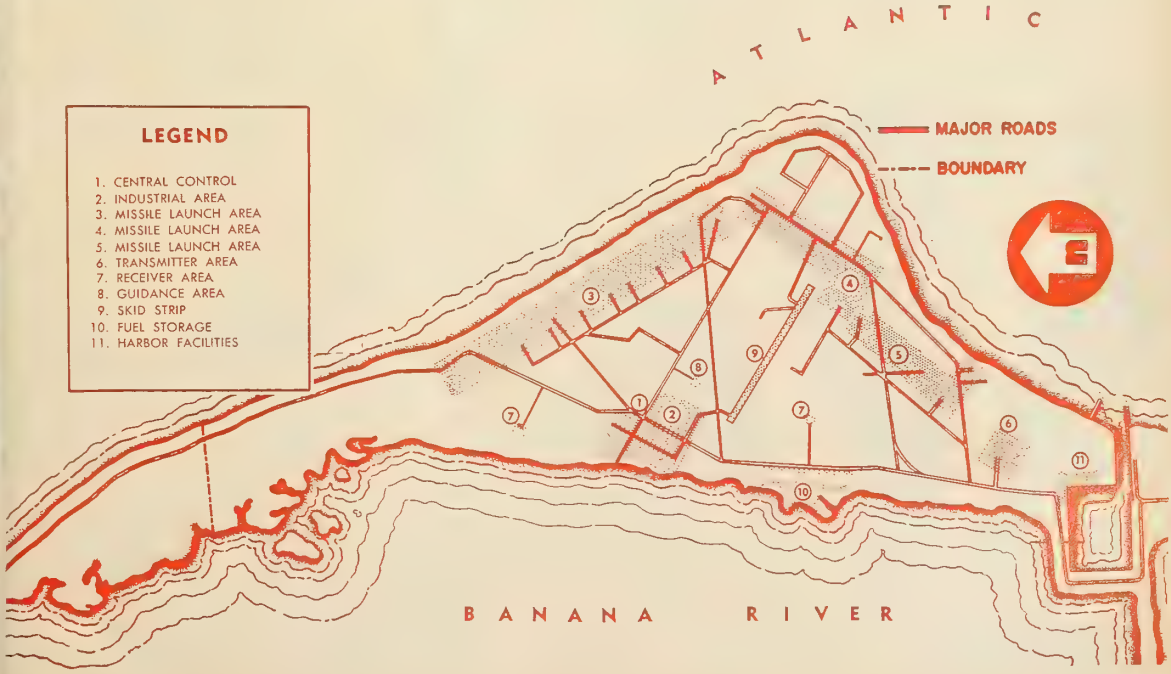
A fishing license, costing $2.25 and obtainable at most boat rental and bait houses, is required for fishing in fresh water. Fishing for large-mouthed black bass is very popular in nearby fresh water bodies, such as Lake Poinsett, St. John's River, Lake Washington, and Lake Winder.

Duck and quail hunting is popular in this part of the state during the season, which lasts from about mid-November to the end of January. Deer and turkey hunting may be done on hunting preserves with a license obtainable from the State Game Commission. Local hunting requires a city hunting license.

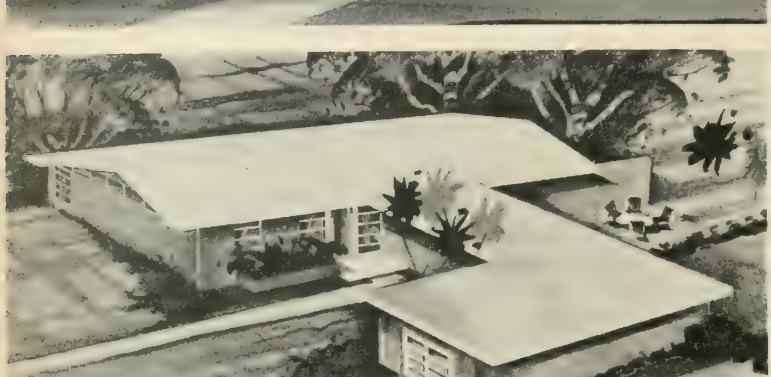
Taxes and Citizenship

Insofar as the state is concerned, a new resident of Florida is a citizen of Florida (a resident being a person domiciled in the state). One is not eligible to vote, however, until he has resided in the state one year and in the county and precinct six months. Declaration of intention to become a citizen may be filed in person by a new resident in any courthouse. Florida has no poll tax.

Florida has none of the penalizing taxes now common to most states. Its constitution prohibits the state from imposing taxes on incomes (either individual or corporate) and on real property and permits no state inheritance tax, although sharing in that which is federally imposed. The state's finances originate solely from excise and sales taxes, occupational and other licenses of the usual character. The state sales and use tax is similar to that in effect in the majority of other states. Exempt from sales tax are: food,







Beautiful, modern Capehart housing units for Patrick AFB airmen.

medicine and some farm supplies.

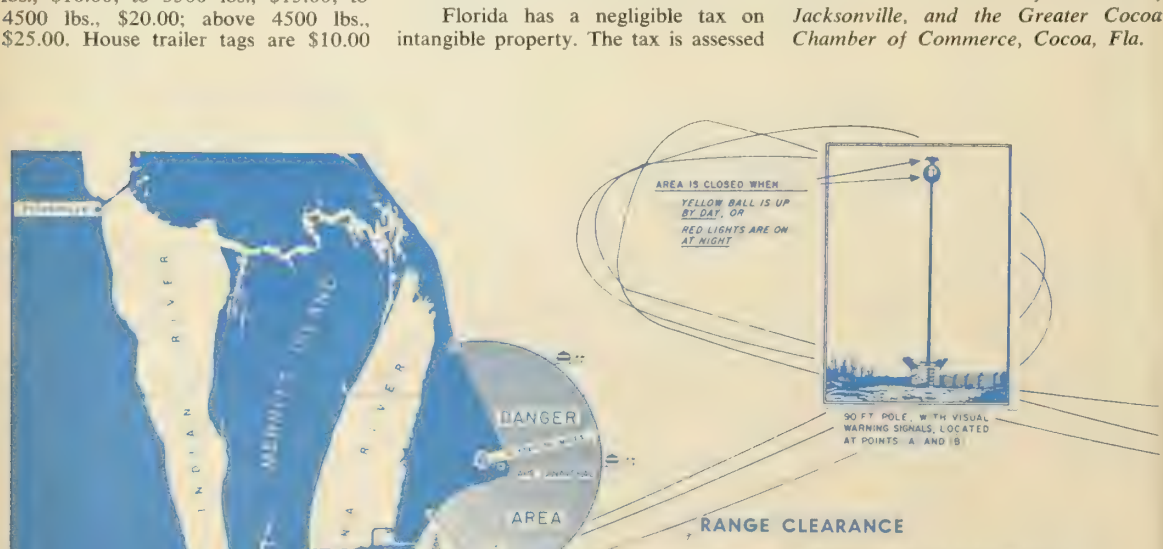
There is no property (ad valorem) tax in Florida on automobiles, but the state imposes a license fee as follows: weight up to 2000 lbs., $5.00; to 2500 lbs., $10.00; to 3500 lbs., $15.00; to 4500 lbs., $20.00; above 4500 lbs., $25.00. House trailer tags are $10.00 when it is used on the highway; when used as a home, it is taxed as personal property (see below). Nonresidents, entering children in public schools, are required to purchase Florida tags for automobiles used in the state.

Florida has a negligible tax on intangible property. The tax is assessed at full value and is 10¢ per $1000 on money and $2.00 per $1000 on stocks, bonds, notes and mortgages. This tax does not cover savings bonds.

Occupational and business licenses are required by the state, counties and cities. Other city and county taxes are difficult to compile because of the variety of conditions, localities, etc. To secure information on these various local taxes, the Florida Chamber of Commerce suggests writing to the tax assessor in both the city and county in which you are interested, regarding the following subjects: Real Property: Counties and cities levy property (ad valorem) taxes, but may not tax a homestead except where the assessed value is over $5000, and then only on that part exceeding this minimum. Personal Property: These are city and county taxes and there is a $1000 exemption for the heads of families.

Taxation in the Patrick AFB locality are approximately as follows: Taxes on nonhomestead-exempt property in Cocoa, 10 mills; state and county 61.85; in Rockledge, 9 mills; state and county, 70.35. On homestead-exempt property in Cocoa, 2.7 mills; Rockledge, none; state and county, none. Property is evaluated at about half its sales value.★

Facts, figures and illustrations in this article have been compiled and digested by m/r from material and statistics furnished by the Air Research and Development Command, Office of Public Information, HQ, Patrick AFB; The Florida Chamber of Commerce, Jacksonville, and the Greater Cocoa Chamber of Commerce, Cocoa, Fla.



RANGE CLEARANCE

Crash boats also patrol the area and warn small craft. Also cleared of ships is the area "downrange" where the missile impacts in the water. The section between the five mile danger zone around the Cape and the impact site is monitored by aircraft and radar to insure the safety of any shipping in the area. On the basis of reports from all these search units the range clearance officer determines the safety involved and authorizes the launching.

WHY ASTROPHYSICS?

Astrophysics applies the laws of physics to the study of the universe, according to the dictionary. But only the history book reveals that it was the study of the universe which gave impetus to the development of physics. The basis of all science is precision measurement. However, without the universe around us such concepts as precise time and precise position may never have evolved.

The ancients observed the regular motion of stars, caused by the earth turning on its axis—uniformly, with hardly any variation in the 24-hour period. Nowhere on earth do we have an example of such uniformity.

If we look at the history of astrophysics, we find a number of breakthroughs. Some are related to the development of new instruments, others are theoretical in origin. Our ideas about the nature of the universe are based on what we see and the better we see, the greater our understanding.

The first and most important breakthrough was the invention of the telescope which, in the hands of Galileo, led to the first real discoveries in astronomy. In his "Sidereal Message" Galileo describes very excitedly the "many great wondrous spectacles" which he saw when he first picked up his telescope.

His first discovery—the mountains of the moon whose height he measured very crudely; his next discoveries—the moons of Jupiter and the phases of Venus, which proved that other planets have satellites and also give great impetus to the Keplerian solar system theories.

Galileo was the first man to view the Milky Way and recognize that it is made up of countless stars. Larger and larger telescopes have evolved up to the 200-inch Mount Palomar instrument which now looks far out into space. Here in 1610, physics, for the first time, advanced astronomy.

The stimulating effect of the astronomical discoveries on physics itself must not be overlooked. Nowhere on earth are there phenomena as regular and therefore as simple as in the workings of the universe, especially in the solar system. Objects on earth never move under gravity alone. There are always winds, air friction and other disturbing elements.

It is no wonder that Newton formulated the simple law of gravitation (in 1666) through astronomical observations and only later applied it to phenomena on the earth. Now we use it to describe the motion of earth satellites, and ballistic rockets moving freely outside the atmosphere under the influence of the earth's gravitational field alone.

The next great advance was the invention of the spectroscope, the instrument which can analyze the light from celestial objects after it has been collected by a telescope. It is the instrument which tells us what kinds of atoms contribute to the light.

The spectroscope, first in the hands of Kirchhoff who in 1862 applied it to the sun, has been and still is the most important tool of the astrophysicist. It has been used to deduce the composition of stellar atmospheres and of interstellar gas.

It can tell us the temperature of the earth's atmosphere and the nature of the surface of Mars and Venus. Spectroscopy, however, really became valuable only after the development of modern atomic physics, which provided the key to why atoms emit light of particular colors and with particular intensities.

Nuclear physics has also found its application to astronomy, and a very important one. It has given us a means of understanding the ultimate energy sources for the stars. We now know what the interior of the stars consists of, the relative abundances of hydrogen and helium and of the heavier elements and we can calculate how rapidly these materials are burnt up in order to provide the energy.

We can even calculate the evolution of stars, their past behavior and past energy output and we can predict their future behavior and their eventual death. As a result of our increasing knowledge of nuclear physics we now know more about the internal constitution of stars than we do about the internal constitution of the earth itself.

The development of radio astronomy was a major breakthrough closely tied to the technological developments of electronics. We can now "see" objects in space through radio waves.

They are not subject to absorption by interstellar dust which limits the visible light radiation. We can, therefore, look much farther into the region of the galactic center than we can with optical telescopes. And we can get new data on celestial objects by studying their emission of radio waves.

There have been discoveries of new objects, such as the radio stars which are slowly being identified. There has also been much activity in the science of magnetohydrodynamics, one task of which is to explain the production of radio noise in the universe as well as cosmic ray origins.

But these advances are only the beginning. A new tool of technology has arrived which will push astrophysics on to greater horizons—the rocket. Already high-altitude rockets have made pioneer explorations above the ocean of atmosphere which screens up from most of the radiation coming from outer space.

We have already been able to "see" the sun in its ultraviolet light but only for short periods. The artificial satellite will eventually allow long-term observations of solar ultraviolet and X-rays. The *Vanguard* project will be of major importance for astrophysics. So will extensions of the vertical rocket techniques to extremely high altitudes.

The recently announced Project *Far Side* will carry instruments to unbelievable altitudes, measured in earth radii, and eventually to the limits of the earth's gravitational field. To begin with, these observations will be crude and rather simple, but as larger rockets are developed the vehicles will become heavier and more intricate and the instrumentation carried out into space will become more elaborate.

In the meantime, the study of the universe may give us another insight into physics. Cosmology may solve the most fundamental problems of all; gravity and the ultimate nature of matter. The steady-state model of cosmology which assumes that matter is created spontaneously and uniformly throughout space may in the end allow us to glimpse the properties of subnuclear matter and of antimatter.

Already theoretical speculation is rife on whether antimatter obeys the same laws of gravity as ordinary matter. But this is a hypothesis which we may never be able to test in the laboratory. For confirmation we must look to the cosmos itself.

1957 Liquid Propellant Round-up

By the Editors of m/r

BY THE TIME our GALCIT Project had formed and actually got under way, the Germans had a head start in liquid propellant rockets. By 1931 a 660-lb. thrust liquid engine had been developed in Germany, and by 1934 a rocket using this engine was successfully launched. Peenemuende had developed a 3300-lb. thrust engine by 1939.

It was not until 1939 that the Jet Propulsion Laboratory undertook the development of liquid propellants. On July 1, 1940, JPL started work on nitric acid systems. The aim: develop a liquid propellant rocket to deliver 1000 pounds of thrust for one minute. Starting with gasoline as fuel, ignition problems and combustion instability were encountered (the engine worked properly about 80% of the time).

At about the same time, a group of researchers at the Naval Experiment Station (Annapolis, Md.) also had the same combustion trouble with a nitric acid-gasoline combination. It was found that aniline was spontaneously combustible (hypergolic) with red fuming nitric acid.

In April, 1942, an A-20A attack bomber was equipped with a 1000-lb. thrust acid-aniline rocket. During the tests some 44 successive runs were made without any misfires or explosions. This marked the first liquid propellant rocket assist takeoff (RATO) in the U.S.

After the successful RATO, Aerojet Engineering Corp. (now Aerojet-General) took over to manufacture liquid units. However, liquid engine use was dwarfed by the efforts devoted to solid RATO and artillery rockets.

A Signal Corps assignment in 1944 required a rocket to carry 25 pounds of meteorological instruments to an altitude of at least 100,000 feet. JPL started to work on this project by first firing a missile booster *(Baby WAC)* in July, 1945. Test of the *WAC Corporal* was made in autumn 1945. The engine, delivering 1500 lbs. thrust for 45 seconds was an acid-aniline engine built by Aerojet.



One of the world's more highly developed liquid rocket engines—Reaction Motor's power plant for the North American Aviation X-15 rocket research plane undergoing static test.

On the East Coast the scene was somewhat different. A number of ardent American Rocket Society members (Lovell Lawrence, Jr., James H. Wyld, John Shesta, and Franklin Pierce) had been conducting Sunday afternoon rocket shots. They formed Reaction Motors, Inc. in 1941 and by November, 1942 successful runs were made at over 1000-lb. thrust. They upped this to 3400 pounds by May, 1943.

The end of the war, however, showed that the U.S. was lagging far behind in development and production of large liquid rockets. The V-2 was immediately accepted as the workhorse around which additional developments nucleated. There then followed a growing number of government, industry, and research groups (Tables 2, 3 and 7). A rundown on the latest activities follows:

AEROJET-GENERAL CORP. Working on the *Titan* (LOX), second-stage *Vanguard* (acid) liquid rockets. Also *Aerobee-Hi* (acid) and liquid underwater units (lithium). Now building three acid-JP rocket sleds.

AMERICAN MACHINE & FOUNDRY CO. Working with ethylene oxide and alkyl nitrates for ICBM APUs at its Pacoima, Calif., facility.

AMERICAN ROCKET CO. Recently entered the liquid rocket field with a new monopropellant combination. Also working on new high energy fuels.

ARMOUR RESEARCH FOUNDATION. Extensive research work on stabilization of liquid ozone. Also: chemistry of the boron exotic fuels.

BELL AIRCRAFT CORP. Developed powerplant for *Nike Ajax* (acid) and liquid rocket for *Rascal.*

CALIFORNIA RESEARCH CORP. Working toward improvement of properties of nitric acid systems.

CURTISS-WRIGHT CORP. Developed a LOX-gasoline ATO and a throttleable motor for Bell X-2. Thrust is 12,000 pounds. Major propellant emphasis: LOX.

ETHYL CORP. Doing research in development of monopropellants and fuels. Products: alkyl nitrates and alum-

TABLE 1

ON THE SHELF LIQUID ENGINES

Model	Length (Overall) (in.)	Diameter (Maximum) (in.)	Weight (Dry) (lb.)	Thrust (lb.)	Burning Time (sec.)	Mfr.	Oxidizer	Fuel	Notes
Aerobee-Hi				4,100	53	A	NA	XY	Niafrak nozzle, ceramic lined.
AJ24-1 (YLR45)	74	30			45	A	NA	JP	B-47 RATO (2 retractable chambers on each side of fuselage).
AJ-10-24	130	15				A	NA		*Aerobee* liquid booster.
LR63AJ-1	144	12				A	NA	JP	F-84 RATO & Auxiliary Thrust (1 permanent chamber in tail).
1500N4C	56	19	210	6,000		RMI	LOX	ALC	Used on X-1, D-558-2, and XF-91. 4 cylinders.
XLR10-RM2			250	20,000	60	RMI	LOX	ALC	*Viking* engine.
ESM				50,000	8	NAA	LOX	ALC	Edwards Sled engine.
Atlas				135,000	180	NAA	LOX	JP?	Uses two tandem boosters.
				100,000			LOX	JP?	Sustainer.
Corporal						R	NA	XY	
	132	32	60	4,000		C-W	LOX	JP	ATO.
XLR-25CW-1				12,000		C-W			Bell X-2 engine, stop, start, throttles.
A1				13,000		GE	LOX	ALC	*Hermes* 1 engine.
Nike				2,600	35	B	NA		*Nike* A sustainer.
Redstone				75,000		NAA	LOX	ALC	*Redstone* engine.
X405				27,000	150	GE	LOX	JP	Stage 1 *Vanguard*.
AJ10-37				7,500	100	A	NA	UDMH	Stage 2 *Vanguard*.
Jupiter				135,000		NAA	LOX		*Jupiter* engine.
Titan				300,000		A	LOX		Booster.
				60,000					Sustainer. *Titan*.
TPM			4,250	50,000	8	RMI	HP	JP-4	Transonic pusher engine for Edwards track, uses 3.
				150,000					
SPM			14,300	62,000	9	RMI	HP	JP-4	Supersonic pusher engine for Edwards track, uses 8.
				500,000					
AJ10-28	160			35,000		A	RFNA	JP-X	SNORT engine, uses 1.
AJ10-36	196			35,000		A	RFNA	JP-X	SNORT engine, uses 1.
AJ10-33	233			35,000		A	RFNA	JP-X	SNORT engine, uses 3.
				105,000					
X-15				60,000	60-180	RMI			Motor for NAA X-15.

A: Aerojet-General.
RMI: Reaction Motors, Inc.
NAA: North American Aviation.
R: Ryan.
C-W: Curtiss-Wright.
B: Bell Aircraft.
GE: General Electric.
UDMH: Unsymmetrical dimethyl hydrazine.
RFNA: Red fuming nitric acid.
HP: Hydrogen peroxide.
JP-4: Kerosene.
ALC: Alcohol (ethyl).
XY: Xylidine.
NA: Nitric acid.
LOX: Liquid oxygen.
JP-X: 40% UDMH, 60% JP-4 with aniline-furfuryl alcohol starter fuel.

inum organics.

EXPERIMENT, INC. Engaged in research on liquid propellants.

FOOD MACHINERY. Its Becco Div. is a major supplier of high strength hydrogen peroxide while Chlor-Alkali Div. supplies UDMH fuel.

GARRETT CORP. Has specialized in liquid APUs (viz. alkyl nitrates).

GENERAL ELECTRIC CORP. With research in all phases of propulsion, GE's major propulsion task is to develop and produce first-stage *Vanguard* engine (X405). Operates large static test stand at Ballston Spa, N. Y. Major propellant emphasis: LOX.

LOCKHEED AIRCRAFT CORP. Now developing its own central California research facility and construction of large-scale static test facilities.

NORTH AMERICAN AVIATION, INC. Big gun in liquid rocket field, has liquid powerplants for *Atlas, Navaho, Redstone*, and *Thor*. Operates huge stands in Santa Susana Mountains. Building *Atlas* engine plant at Neosho, Mo. Major propellant emphasis: LOX.

OLIN MATHIESON CHEMICAL CORP. Now aligned with RMI under OMAR program. Major propellant tasks: production of hydrazine and derivatives, and Zip fuels.

PENNSALT CHEMICALS. Pushing development of fluorine and fluorine chemicals for liquid rockets.

REACTION MOTORS, INC. Active in liquids for aircraft propulsion, ATOs, and launching systems. Also working on two large rocket sleds for Edwards AFB track.

RYAN AERONAUTICAL CO. Producing *Corporal* rocket engines.

WYANDOTTE CHEMICAL CORP. This producer of ethylene oxide is now entering production of auxiliary propulsion systems using this material.

Liquid Status

During the twenties, thirties, and early forties of this century, the basis for all our liquid rocket systems was established. There was Goddard and the VfR with liquid oxygen, Walther, BMW, and JPL with hydrogen peroxide and nitric acid. With the exception of hydrogen peroxide, the LOX and acid systems power all our present "modern" liquid rockets. Of these combinations, LOX has emerged as the liquid king.

It may seem incredible that our *modern* missiles are powered by *ancient* propellants. Modern solid systems, a scant ten years old, are competing hard and heavy with these liquids in performance, scale-up, and reliability. The difficulty has been not so much in the inadequate liquids themselves but in finding better replacements. Thus, because of the lead time required for new systems, these present liquids, as bad as they are, simply could not be dropped.

The properties of the liquid twins (LOX and nitric acid) have been known for some time (and this includes performance characteristics). Continuing

efforts have gone into improving and enhancing properties. However, most of the efforts have gone into time-and dollar-consuming engineering—that is, translating an expanding propellant system into an expanding missile system.

LOX is now the undisputed liquid king. Its realm is the IRBM, ICBM and the first-stage *Vanguard*. Although performances have been increased some 50 seconds since World War II, the greatest triumph has come in the evolution of mighty engines.

Both government and industry feel that these large engines will probably form the propulsion basis for man's first real trip into space—at least for establishing the manned satellite and the first rocket to the moon. However, it has cost us ten years to do this. It may be another ten years before liquid ozone or fluorine systems start displacing LOX.

The hot-tempered nitric acid systems have not been so regal. Nitric acid has had early favor. For example, the *Nike* (now *Nike Ajax)* liquid system was ready about ten years before the overall system (including guidance) caught up with it and was ready for operation. This overall systems difficulty has been responsible for the slow liquid progress.

Although the bugs in the acid systems had been pretty well worked out by the Germans, it remained for us to inherit two major difficulties. One, the matter of scale-up, is now near solution. The other—storage and handling—is about to put nitric acid systems into the "use as soon as possible" category.

One major lag in the advancement of liquid systems has been the failure to evolve a *practical* monopropellant suitable for primary propulsion of large missiles. All present monopropellants, hydrogen peroxide, alkyl nitrates, tetranitromethane, and ethylene oxide have failed for big unit consideration. Only one, hydrogen peroxide (as a bipropellant system), is now going into a medium-thrust engine. The rest of the monopropellant lot have turned to the gas generator realm for their continued existence. Thus, a major breakthrough is needed to stimulate the monopropellant picture.

Hardware developments have come as a result of slow-plodding rather than breakthroughs. Thus, the thrust levels have gradually crept up. Ten years ago, the 35,000-lb. thrust V-2 engine was a monster. Today's ICBM engines produce thrust at about four times this level. However, the average liquid rocket (viz., the IRBM and the two liquid *Vanguard* engines) operate at much lower levels. Thus, by grouping or modifying existing engines using existing liquids, our hardware needs may be solved for future applications.

As the newer propellants come along they can be evaluated and applied in available engines with or without modification. Liquids have established a good growth pattern that has not been duplicated in solid engines.

Although liquid rockets have established a scale-up technology and have also provided for performance increases, the handling and reliability problems will continue to plague liquids.

The handling problem of liquids, bad as they now are, may tend to worsen with the two potential oxidizer contenders—ozone and fluorine. Both can be handled safely but require extreme care. Whether these two can be engineered to a "GI-proof" status is difficult to say. However, improvement of the handling characteristics may already be under way in classified work.

Despite handling improvements, it is doubtful if ready-to-go, long-storage capabilities comparable to the new solids can ever be expected. The liquids have only been favored where the highest performance is the most important parameter.

It is in the reliability department that even the best possible liquid systems can be considerably improved. Present reliabilities are on the order of 95-97% with the hope that 98-99% can eventually be achieved. For manned craft even this may not be enough. It should be noted that the U. S. still is only in the research vehicle stage in its liquid propellant rocket aircraft.

What of the ultra-energy liquid systems such as free radicals? Although research in this field is still embryonic, it is unlikely that handling will be materially improved. As a matter of fact, it looks like the solid and liquid fields will merge here—solid storage and liquid or gaseous use.

The applications picture for liquids is such that they will continue to grow but are lagging somewhat in the specialized race with solids. Of course, the future applications for all rocket power are expanding at such a rate so that it would be hard to say whether solids or liquids would be winning sales-wise ten years from now.

The liquid rocket industry has accomplished a herculean task—translating the hot laboratory combinations into workable systems. Now that the pattern is established, liquids will continue to push toward the limits of chemical propellants.

TABLE 2
GOVERNMENT LIQUID ACTIVITY

Group	Location	Activity
Air Force		
Flight Test Center	Edwards AFB, Calif.	Rocket aircraft and test stand work.
Holloman AFB	Alamogordo, N. M.	Flight tests.
Missile Test Center	Cocoa, Fla.	Static & flight tests.
Wright ADC	Dayton, Ohio	Propellant evaluation & static testing.
Army		
Redstone Arsenal	Huntsville, Ala.	Propellant evaluation & static testing.
White Sands Proving Ground	White Sands, N. M.	Flight & static tests.
NACA		
Lewis Flight Propulsion Lab.	Cleveland, O.	Propellant evaluation.
Navy		
Air Rocket Test Station	Dover, N. J.	Large test stand.
Missile Test Station	Point Mugu, Calif.	Flight tests.
Ordnance Test Station	Inyokern, Calif.	Research & development.

Liquids Growing

During World War II and the bustling period immediately afterward, about $1 billion went into liquid propellant rockets. In the ten years since the war another billion has been spent. At the present time, the liquid rocket business is worth about a billion per year, and it may double in another two to five years. Unofficial estimates break down the annual liquid rocket industry as follows:

	Millions
Nose cone, payload, and guidance	$650
Airframe	100
Powerplants	100
Propellant chemicals	100
Other chemicals and materials	25
Miscellaneous	25

This includes research, development, production, training and testing, and maintenance.

In addition to the industry lineup

TABLE 3
INDUSTRIAL ACTIVITY IN LIQUIDS

Company	HQ	R	D	P	T
Aerojet General Corp.					
Azusa, Calif.	x	x	x	x	x
Sacramento, Calif.		x	x	x	x
American Machine & Foundry Co.					
New York, N. Y.	x				
Pacoima, Calif.		x	x	x	x
American Rocket Co.					
Wyandotte, Mich.	x	x	x		
Ypsilanti, Mich.					x
Armour Research Foundation					
Chicago, Ill.	x	x	x		
Bell Aircraft Corp.					
Buffalo, N. Y.	x	x	x	x	x
Wheatfield, N. Y.					x
California Research Corp.					
Richmond, Calif.	x	x	x		
Continental Aviation & Eng. Corp.					
Detroit, Mich.	x	x	x		
Curtiss-Wright Corp.					
Woodridge, N. J.	x	x	x	x	x
Ethyl Corp.					
Detroit, Mich.	x	x	x		
Experiment, Inc.					
Richmond, Va.	x	x	x		x
Food Machinery & Chemical Corp.					
New York, N. Y.	x				
Becco Chemical Div.,					
Buffalo, N. Y.		x	x	x	
Westvaco Chlor-Alkali Div.,					
S. Charleston, W. Va.				x	
Garrett Corp.					
Los Angeles, Calif.	x	x	x	x	x
General Electric Co.					
Schenectady, N. Y.	x	x	x	x	
Ballston Spa, N. Y.		x	x		x
M. W. Kellogg Co.					
Jersey City, N. J.	x	x	x		
North American Aviation, Inc.					
Los Angeles, Calif.	x				
Rocketdyne Div.,					
Canoga Park, Calif.	x	x	x	x	
Santa Susana, Calif.			x		x
Neosho, Mo.				x	
Olin Mathieson Chemical Corp.					
New York, N. Y.	x				
Lake Charles, La.				x	
Niagara Falls, N. Y.				x	
Pennsalt Chemicals Corp.					
Philadelphia, Pa.	x	x	x		
Propulsion Research Corp.					
Santa Monica, Calif.	x	x	x		x
Reaction Motors, Inc.					
Denville, N. J.	x	x	x	x	
Dover, N. J.			x		x
Ryan Aeronautical Co.					
San Diego, Calif.	x	x	x	x	
Wyandotte Chemical Corp.					
Wyandotte, Mich.	x	x	x	x	x

HQ: Headquarters *D: Development* *T: Testing*
R: Research *P: Production*

TABLE 4
DEMAND VERSUS SUPPLY
LIQUID OXIDIZERS & FUELS

Material	U.S. Production 1956 (est.) (short tons)	Rocket & Missiles Use, 1956 (est.) (short tons)
Oxidizers:		
Alkyl nitrates	100	10
Ethylene oxide	500,000	100
Liquid fluorine (capy)	40,000	25
Hydrogen peroxide (100%)	24,000	1,000
Liquid oxygen (95%)	742,000	10,000
Liquid ozone	1	1
Nitric acid (100%)	2,500,000	15,000
Tetranitromethane	10	10
Fuels:		
Ammonia (100%)	2,800,000	10
Ethanol (100%)	1,000,000	1,000
HEF (alkylated boranes)	10	10
Hydrogen (100%)	900	1
Hydrazine	100	15
Hydrazines, alkylated	2.000	1,500
JP (4&6), USAF only	7.000.000	1,000
RJ-1 (petroleum ramjet fuel)	1.750	1,750
RP-1 (petroleum rocket fuel)	1.750	1,750

TABLE 5
CALCULATED PERFORMANCES OF LIQUID PROPELLANTS

Oxidant	Fuel	Oxidizer/Fuel Ratio	Specific Impulse (sec)
LOX-LOZ (70-30)	JP-4	2.3	253
LOZ (100%)	JP-4	1.9	266
LOZ (100%)	Hydrogen	3.2	369
Fluorine	JP-4	2.6	265
Fluorine	Diborane	5.0	291
Fluorine	Hydrogen	4.5	352

TABLE 6
BEYOND CHEMICAL COMBINATIONS:
THE FREE RADICALS

Combination (on a mol volume basis)	Theoretical Specific Impulse (sec)
2.8H+1NH	410
2.2H+1BH	420
5.0H+1CH	492
0.5H+1H	1040
H (alone)	1280

The tables on this page present the U.S. liquid rocket industry in a statistical nutshell. Listed in Table (3) above are 21 companies in the liquid propellant rocket business. All-told they have offices and facilities at 34 locations around the United States. Their activities range from work on gas generators with a few pounds thrust to ICBM motors whose thrust runs into the hundreds of thousands of pounds. If any doubt still remains that the chemical industry has a big stake in the business of missiles and rockets, Table (4) should dispel it. The other two tables give an idea of what's in store for the future.

shown in Table 3, most aircraft firms are engaged in various rocket activities. This trend has recently spread to the automotive and chemical industries. The employment force for liquids, therefore, is much larger than for the solid rocket industry.

When all supporting personnel (including administration and research) are included, an estimated 100,000 to 200,000 people are working on liquid missiles and rockets. In two years the figure may increase by another 25,000 and in five years the total force may be near 500,000. Most of the new personnel will be coming from colleges and universities and from the aircraft, automotive, and chemical industries.

Table 4 lists some of the major liquid oxidizers and fuels going into rockets. Major efforts are now going into LOX expansion since all the ICBMs and IRBMs will use this oxidizer. Production of liquid fluorine and ozone is still very small. Nitric acid capacity is still far ahead of use (as is the case for liquid ammonia); however, use of nitric acid seems on the downgrade. Other oxidizers are being made and used only in very small amounts. Petroleum-based fuels are still far out in front over others and still increasing in use despite the new HEF entries.

Hardware Heavy

Since the war a large amount of hardware has become available (Table 5). Thrust levels range from the early 4000-lb. ATO units to the 135,000 ballistic missile booster engines. Burning time ranges from 8 to 180 seconds. It is thus probable that the designer now need not look for completely new engines for future applications.

On the shelf rocket engines are available even for the beginnings of space flight. Tried and proven engines may be clustered or staged to give almost any desired thrust program. Not only will today's liquid rocket engines help to establish the first earth satellite, but it is predicted that they will:

1) establish a manned satellite,
2) impact the moon,
3) make an unmanned circumlunar flight.

Limit Near

Despite the many possible liquid oxidants, only LOX, peroxide, and nitric acid systems have large-scale application. Of these, only LOX systems give the highest performance, at the price of non-storability and messy handling.

Nitric acid, though manageable, gives rise to a host of handling and storing problems. It now looks like acid systems are on the way out. Peroxide, costly and heretofore relegated to auxiliary propulsion, is hanging in the balance. Present liquid systems are now at the 220-240 sec level. And solids are already nipping at liquids in this range.

What of the new line? There does not appear to be any breakthrough in storage and handling of the new high-energy combinations. Therefore, the big push will be for performance. The liquid people are hanging their hats on two techniques for raising specific impulse.

By using hotter burning fuels and building hardware which can take care of higher temperatures and pressures, an upping of some 25-50 seconds may result. A more promising technique will be to switch to new oxidizers.

Research is now under way with the two most promising prospects—fluorine and ozone. Both may put the liquid rocket near the limits of chemical propellants. Thus, an increase of some 50 seconds may be in the offing (Table 6). This push will be a long and costly one. It won't come in a year but may be with us in ten years.

Liquids have managed to keep ahead of solids by virtue of only two major parameters—scale and performance. Solids are now scaling up fast. Liquids can thus keep ahead only by keeping ahead in performance. With this stimulus the picture should prove very interesting.

In the future the greatest hope for a propulsion breakthrough lies in free radicals or nuclear processes. In free radical propulsion, fragments of chemical molecules recombine to form the original molecules, with heat releases much greater than conventional combustion processes (Table 6). For example, combining atomic hydrogen to give molecular hydrogen could give some 90,000 BTU/lb.

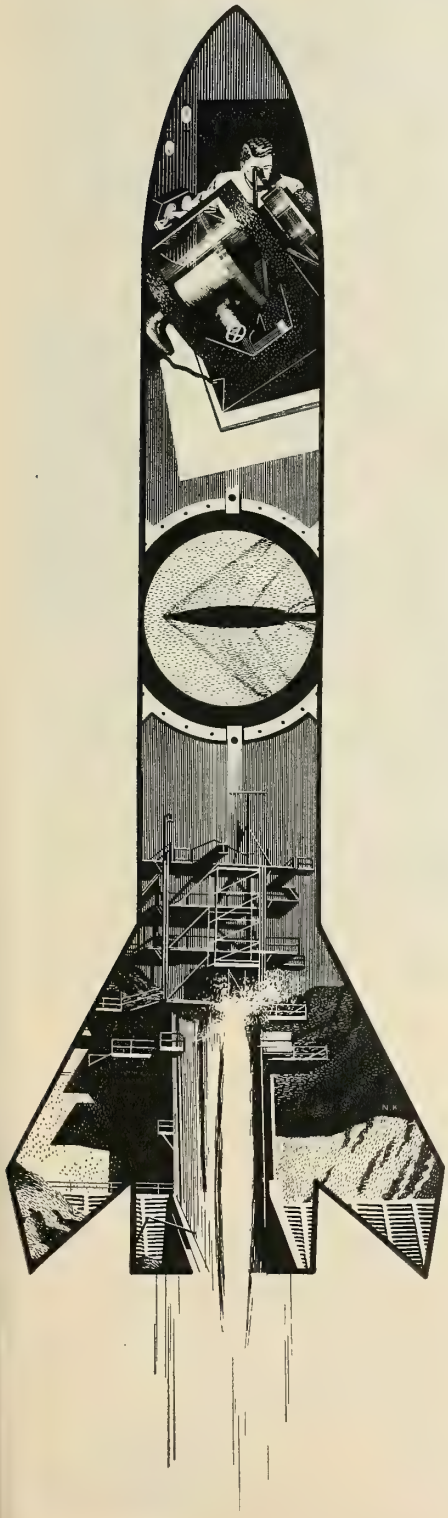
The big problem in free radical propulsion schemes seems to be twofold: storage in large amounts (present technique is to cool to near absolute zero) and the high temperatures of recombination (up to 12,000°F). Then, fission one pound of uranium ^{235} gives off about 1 billion BTUs and in expanding hydrogen could give a theoretical I_{sp} of about 900 seconds.★

TABLE 7

LITERATE LIQUIDS AT THE UNIVERSITIES

University	Activity
California Institute of Technology Pasadena, Calif.	With the Jet Propulsion Laboratory, the student has an opportunity to work in the missile field while learning. JPL also carries out an extensive program in all areas of liquid propellants—research, development, and testing.
University of Detroit Detroit, Mich.	Operates Missile and Rocket Section. Offers student training and conducts research projects in liquid propellants.
Johns Hopkins University Baltimore, Md.	Operates the Applied Physics Lab. at Silver Spring, Md. APL is active in research, development and testing of liquid rockets.
Massachusetts Institute of Technology Cambridge, Mass.	Has available a static test facility operated by MIT Rocket Research Society.
University of Michigan Ann Arbor, Mich.	Operates a propulsion laboratory for liquid rockets.
Ohio State University Columbus, O.	Research and development of premixed propellants and liquid hydrogen rockets.
Princeton University Princeton, N. J.	Its Forrestal Research Center administers Project Squid. Has static test stands and is doing work on liquid ozone.
Purdue University West Lafayette, Ind.	Rocket laboratory conducts research in liquids—mainly nitric acid systems.

Special 111-conductor Rome cable solves tough guided missile problem



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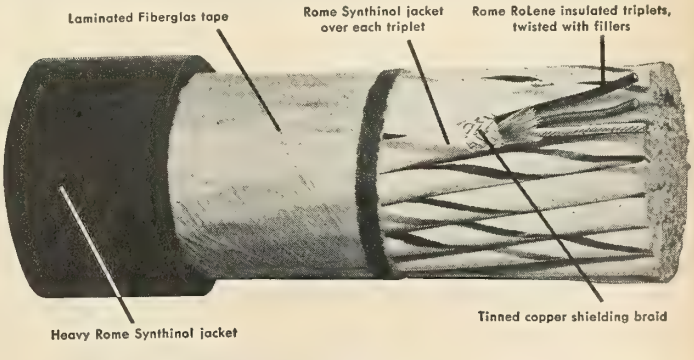
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missiles and rockets

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Propulsion Engineering

By Alfred J. Zaehringer



BORON FUELS: A BILLION DOLLAR MARKET in ten years is the prediction by Olin Mathieson. OM's $5.5 million pilot plant is now delivering high energy fuels to USAF. Second plant, three times present size, will be "on stream" this year. Third plant ($36 million) will start operating by end of 1959. OM is said to be shooting for a fuel price of $1/gal. in ten years. Meanwhile, there is talk that Olin and U.S. Borax will get together and form a company for research and production of boron and lithium compounds.

NEWEST BORON COMPOUND is trimethyloxyboroxine. Anderson Chemical offers the liquid—containing 18.7% boron—in carload quantities. Suggested applications include: jet fuel additive, neutron detector.

ATOMIC OXYGEN, found at high altitudes, could be used as a super "fuel" by jets or ramjets, says USAF. Cambridge Research Center has found a catalyst which kicks atomic oxygen into molecular oxygen with a large energy release.

CHLORYL FLUORIDE has been prepared and studied by chemists in Argentina. The compound, ClO_2F, is a powerful oxidant. A similar oxidant, perchloryl fluoride (ClO_3F) is available in pilot plant quantities from Pennsalt.

DIRECT MEASUREMENT OF ROCKET EXHAUST VELOCITY has been developed at Ohio State University. Seven optical probes are used with a 10 meg, 6-channel chronograph to measure time (in steps of 0.1 microsecond) for a luminous wave to pass between probes. The system is calibrated by means of a gaseous mixture of known detonation velocity. Good checks have been made when compared to other measuring systems.

NOW A ROCKET ENGINE FOR STUDENTS. A group of Aerojet-General engineers have built the "Spark I," LOX-watered alcohol rocket engine of 400 lb. thrust. The regeneratively-cooled motor has an I_{sp} of about 227 sec. and is designed primarily as a training tool.

CARTRIDGE ACTUATED DEVICES using solid propellants are in for study and test by Microloc Corp. of Los Angeles. The Army Ordnance contract comes from Frankford Arsenal. The Conax Corp., Beckman-Whitley, et al. have long been producing explosive actuated valves for missiles. Now a new entry: Atlas Powder Co. is producing a squib-actuated missile switch.

MORE SOLID PROPELLANT ACTIVITY in the Midwest. Standard Oil Co. (Ind.) is expanding lab facilities at its Seymour, Ind. (USAF Freeman Field) plant; completion date is this fall. Olin Mathieson is adding to its high-energy solids facility (Ordhill Works) at Marion, Ill. Propellex Chemical Corp. has moved to a 100-acre site at Edwardsville, Ill. The facility will permit preparation of ammonium nitrate and cast double base propellants to grain sizes of up to 250 lbs.

SHIELDING OF PROPULSION REACTORS is still a big problem. While boral or the boron stainless steels do cut off neutrons, they are still transparent to gamma rays. Even the lead plastic compounds, effective gamma shields, are not the optimum for airborne use because of the very high density. There are now indications that metal-organics or complex organics in combination with light metal carriers may prove effective gamma-ray shielders.

RESEARCH ON FROZEN FUELS has been reported. The technique is to freeze a gas (such as hydrogen) and to use solar energy to melt and evaporate it into a combination chamber. Such frozen fuels might be conveniently stored in space (near absolute zero) and used for space rockets. Work is also underway in determining the physical properties (tensile and compressive strength) of such "iced" materials at these very low temperatures.

ANTI-MATTER may be possible. Just as anti-particles exist for electrical matter, some scientists have theorized that a negative gravitational matter concept may explain several analomies in existing theories.

m/r's personal report from . . .

Rocketeer Sam Hoffman

For Big Jobs Re-use or Controlled Flight Liquid Rocket Engines Now Lead the Field

Manager of North American Aviation's Rocketdyne Division and a member of the American Rocket Society's National Board of Directors, Samuel K. Hoffman oversees design and production of Atlas, Thor, Jupiter and Redstone liquid rocket engines.

Q. *Mr. Hoffman, can you give us an indication of the measure of effort Rocketdyne is putting into liquid propellant engines?*

A. We employ about 10,000 people. Of these, roughly 4000 are in our Engineering Department.

In facilities, we have about 600,000 square feet of floor space in the San Fernando Valley, 130,000 of our Slauson facility in East Los Angeles and 220,000 in our plant in Neosho, Mo. Our test areas include the 1700-acre propulsion Field Laboratory in the Santa Susana mountains and a 200-acre complex in Neosho.

Our purchases are running at slightly better than $70 million a year and the weekly payroll is about $1,250,000.

Q. Mr. Hoffman, will you please outline the role of liquid propellants in the field of missiles today?

A. Liquids today are the predominant type of propulsion in large missiles where their unlimited thrust, relatively small size, precision cutoff, high specific impulse, variable thrust and gimballing ability are particularly suited.

Liquids are also being used in some small missiles where a need for one of their unique characteristics outweighs the simpler structure of solid propellant motors.

I think there is no question in anyone's mind that present liquid propellant engines are capable of putting us into the space flight business. Certainly, the refinement of our present power plants is making a large contribution toward that future. The question of when is largely one of money.

Another application for the liquids is in the field of manned aircraft where the characteristics of long duration operation, safety, repeated on-off operation, thrust control and re-use are vital.

Q. Is this the X-15 sort of thing you're talking about in manned rockets?

A. Yes, the X-15, glide or skip bombers, rocket boost takeoff for some future ramjet airliner maybe—any use where the rocket motors are recovered or brought back for re-use.

Q. The Cook rocket test sled used a Rocketdyne engine. Isn't this a good example of a re-usable engine?

A. Yes. The best information we have is that it made over 100 runs with only routine maintenance—no major replacements. And in 130-to-140 runs the only failures were a couple of valves.

Q. This is quite a testimonial on the re-usability of liquid rocket engines, isn't it?

A. Yes. When we delivered the engine, we predicted 300 runs before it would wear out, and it could well be a lot more than that.

Q. What about the cost of liquid propellant engines compared to solids?

A. For present one-shot applications, it depends largely on how the engine is to be used, which is cheaper. However, when the day comes that you can recover or desire to recover a missile powered by a rocket engine, the liquids will really come into their own. Then they'll be quite cheap. Like your automobile, you put fuel into it and run it; you make one trip and come back, fill it up with fuel again and then get on your way.

Q. Doesn't this seem to indicate that insofar as any possible potential commercial application of the chemical rocket propulsion is concerned, liquids are well in the lead?

A. I believe so, and I believe there'd be general agreement on that.

Q. Do you have any trouble turning a liquid rocket on and off?

A. When you say you have no trouble doing any of these things, it's a relative thing. The engines we work with today are sort of in the Model T stage. There are still troubles, but they are a lot different today than they were two years ago. And progress will be much faster because we have more engines to work with, more experience. Progress, insofar as reliability is concerned, is going along at a tremendous rate.

Q. Within the limits of security, for which missiles is Rocketdyne making engines?

A. We are building liquid propellant engines for the Convair *Atlas*, Douglas *Thor*, Army-Chrysler *Redstone*, Army *Jupiter* and until recently, the Air Force *Navaho*.

Q. Well, doesn't Rocketdyne supply the entire power package—engine, pumps, fuel tanks, valves, etc?

A. No. We supply the engine itself and its immediate supporting equipment. Somebody else supplies the tanks, lines leading to them, valves, etc.

Q. Does Rocketdyne have any licensing or exchange know-how agreements with any companies abroad?

A. We have a license agreement with Rolls-Royce. They have a license from us to build our engines.

Q. You are restricted by security on just what plans and specifications you can supply under such an agreement, aren't you?

A. Yes.

Q. What is the largest liquid propellant engine NAA has fired—in terms of straight thrust—in terms of specific impulse?

A. We are not in a position to give you the highest thrust or specific impulse figures that we have reached, but we can tell you we have produced an engine with the highest thrust rating that we know of to date—and by a considerable margin.

Q. Can you comment on the cost of liquid propellant motors?

A. Costs today, even in small quantities, are something on the order of one third of what they were when production first started. They may go down still more. Basically, cost is associated with quantity. If Ford were making 1000 cars a year instead of in the millions, we couldn't afford to buy one. And that's about the same situation

here. Quantities are so small that high production techniques are just not applicable.

Q. Is Rocketdyne doing any research and development on solid propellant rocket motors?

A. Yes, during the past five years we have engaged in several developmental projects and subsequent pilot production programs.

Q. Can you give us some estimate of the measure of improvement in specific impulse and mass ratio in liquid propellant engines by the use of additives?

A. The first thing I think we should do is define the term "additive". We will assume that an additive will constitute no more than 20 per cent to 30 per cent of the propellant into which it is placed. With this definition in mind, performance gains, in the order of 3 per cent to 5 per cent, may be realized through the use of additives in certain fuels and/or oxidizers. This gain in specific impulse performance would correspond roughly to 10 per cent in mass ratio for missiles of the intermediate and intercontinental ballistic type.

Q. What are some of the more promising additives?

A. The probable future trend in rocket fuels and oxidizers will be toward increased hydrogen content in fuels and increased fluorine content in oxidizers. On that basis, promising additives would include hydrazine and other compounds with concentrations of either of those two elements.

Q. What's the general consensus on the future role of fluorine, boranes, etc?

A. It is probable that the trend in oxidizers will be toward increased fluorine content. With boron, a great deal of experimental and analytical work faces us before we can be certain of the gains to be had.

Generally speaking, there are inherent problems in the future use of high-energy propellants, but we certainly can't rule them out on chemical grounds. The engineering problem of adapting them to reliable powerplants, or powerplants to the propellants, is not insurmountable.

Q. We understand that the temperature limitations of materials place an absolute limit on improvement of specific impulse of 40 per cent compared to current levels. Is there any known device by which this ceiling may be breached with liquid propellant motors?

A. The energy limit which has been quoted widely recently—and we refer to it as being a possible improvement of 50 per cent rather than the 40 per cent you mentioned—deals with molecular species and the energy derived from their normal chemical, or valence, bonds. The limit is one of propulsive energy rather than temperature. For instance, the combustion temperature of the highest specific impulse theoretically available—that of 373 theoretically possible through the combination of fluorine and hydrogen—burns with a temperature of about 5100°F. The second highest, in these theoretical tables, is specific impulse of 364 by oxygen and hydrogen, with combustion temperature even lower—that of 4500°. In contrast to this, the lower specific impulse of 316 from fluorine and hydrazine would develop combustion temperatures of nearly 8000°. The key to the limit of propulsive energy is not temperature but the best combination of high combustion temperature and low molecular weight of products.

It is true, of course, that more energetic fuels and oxidizers, because of their weak bonds and relatively high vapor pressures, will be progressively less capable of handling the high thermal loads which will be impressed upon them in the regenerative cooling passages of future engines.

The ability of the engine materials to withstand the high combustion temperatures associated with the highest performance chemical propellants is not fundamental by limitation in liquid rocket engines since cooling methods are characteristic of this type.

If energy sources other than chemicals are employed, material temperature limitations are a major problem.

Q. Is any consideration being given to development of electromagnetic thrust chambers and nozzles—along the principles of the "pinch" effect that's being worked on for controlled thermo-nuclear rockets? Could this principle be successfully applied to chemical rockets and would it be worth while in terms of mass ratio (considering need for high wattage electric power source, etc.) for large, long-range space vehicles—or do other systems promise more efficiency?

A. It is conceivable that the principle of an electromagnetic thrust chamber based on the "pinch" effect could, someday in the future, be used for propulsive purposes in conjunction with a liquid propellant rocket. I wouldn't want to rule it out.

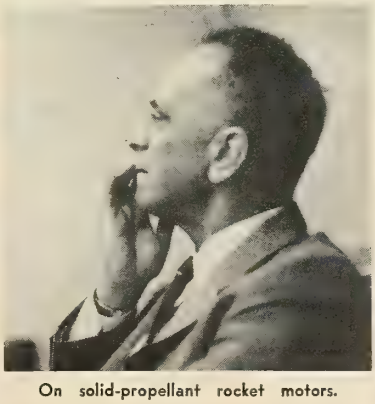
Other systems of electromagnetic motors are also possible. We, for instance, are working for the USAF on a feasibility study of an ion propulsion system using charged ions accelerated by high voltage electrodes to very high velocities.

Q. What effect will the Navaho *cancellation have on Rocketdyne?*

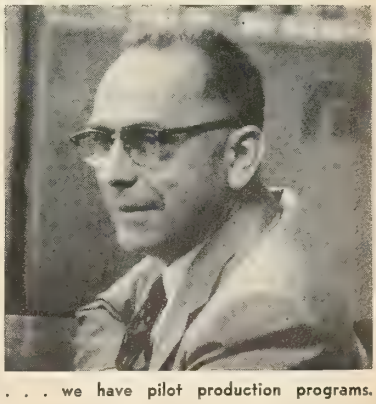
A. This cancellation has had a relatively light effect on Rocketdyne, due to the fact that we are currently engaged in four other major rocket engine programs. Less than 500 persons, or roughly 5 per cent of our work force, were layed off as a direct result of the cancellation.★



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On solid-propellant rocket motors.



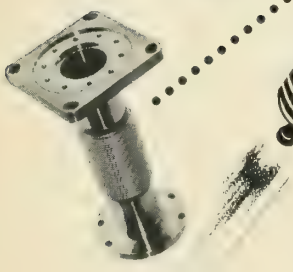
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What's all this talk about EXOTIC PROPELLANTS?



By John F. Tormey
Chief, Research, Rocketdyne

IT IS ALMOST impossible to trace the time when the words exotic propellant first rose full-blown from the brow of a mesmerized rocket engineer. American rocketry has no historian and little recorded history after Goddard.

One recollection of the birth of exotic propellants goes back eleven years to 1946. It was customary then to assign an advanced study unit the task of creating, almost out of nothing, a list of all the liquid propellant fuels and oxidizers that could be purchased, found in handbooks, or conceived of by stretching molecular structural norms to their conceivable limits.

When the lists were prepared, well over half of the chemicals were known and available—alcohol, aniline, 70 per cent hydrogen-peroxide, ammonium nitrate, etc. The rest appeared to be new, unfamiliar compounds, products of uninhibited and sometimes inspired thinking. Such compounds as polyatomic oxygen (O_4), hydrogen molecules containing several atoms, and assorted halogen complexes were typical. Liquid ozone was a regular. Rather than list these things—of which he was generally a little self-conscious in 1946—along with the more regular and familiar chemicals, the rocket propellant researcher invariably made a second list which he titled "exotic," primarily because the testing fitted so well Webster's definition of exotic—"introduced from a foreign land." It was as if by labelling them exotic he had freed himself from any technical responsibility to defend or deliver them.

As is usually the case with the wrong word (exotic is no adjective for a chemical) it found immediate and ready acceptance, appearing in numerous reports.

Examples of exotic chemical compounds outside of rocketry abound everywhere. The application of silicon in the solar battery is a case where physical structure alone brought about something new and exotic. The successful formation of the first synthetic diamonds was an application of a chemical innovation and belief in principles in the face of difficulty.

The free radical particles produced under the Bureau of Standards' current program of fundamental research in that field have brought to light materials which might be defined as exotic both because of irregularity of formation, and also because of the magnitude of energy possible through the recombination of the freed particles. Tetraethyl lead, liquid helium, the boron hydrides, the classic freons, the bubble-forming isocyanates, now rather standard items of chemical commerce, were once exotic by definition.

And so it was also with many of the exotic propellants listed so lightheadly in 1946. They, too, were once exotic. The now familiar 90 per cent hydrogen peroxide was exotic in 1941, when 81.5 per cent produced in Germany was regarded as the highest concentration possible. Liquid flourine met the exotic definition until 1951. These and other exotic propellants are passing from a state of seemingly wondrous alchemy to practical chemical and rocket engineering.

But what of these exotic fuels? Are they above our ordinary considerations in every respect? Hardly. Rocket propulsion principle gives no reason to assume that because a material has been labelled exotic it need no longer obey the thermodynamic principles of rocket combustion and expansion in a nozzle. Like their less sensational brothers—oxygen, hydrogen, peroxide, jet fuel, alcohol and the rest of the other familiar liquid rocket propellants—the exotic species must square with the law which says that performance is a function of the square root of combustion temperature divided by the molecular weight of the products of the reaction. The theory says that the rocket propellants, exotic or otherwise, convert their internal energy into kinetic energy through the formation of energetic exhaust gases. The theory states that this energy will be derived primarily from the exchange of reactant bond energies for the bond energies of the reaction products. The rocket theory states that the molecular weight of the exhaust products is a factor in determining performance. Rocket theory also says that most rocket propellants will be formed from the first two periods of the periodic table.

Here, then are our ground rules. Regardless of the bizarre nature of the exotic propellant, regardless of any incredible property it may have, regardless of the persuasiveness of its advocates, when the exotic substance goes to work in a rocket combustion chamber, it has it no better nor worse than any other propellant because, exotic or not, each must follow the same physical laws, make generally

similar exhaust products, and be bounded by the same temperature and molecular weight conditions.

The exotic propellant has no special license to run up a high molecular weight in its exhaust products. It cannot generate exhaust products whose molecular weight is higher than 20 and it had better generate exhaust products whose molecular weight is less than 10, if it wants to keep its reputation.

On the matter of combustion chamber temperature, the exotic propellant must generate high temperatures at least equal to those generated by conventional propellants (5500°F) and yet its exhaust products must either resist dissociation or be of such chemical composition that a maximum of energy can be withdrawn from them prior to the atmosphere.

Each exotic propellant must be judged strictly on its merit. Now this is a pitifully obvious remark, but the exotic has been known to dim man's reason and blunt his judgment. It is well to keep in mind that there is no easy street in liquid rocket chemical propulsion. No matter how exotic the material may appear on paper, it still has two jobs to perform, to live in our environment and generate thrust on demand.

Exotic propellants can be thought of in the same way one considers exotic foods. To some, *escargots ala Francais* is a most exotic entree, particularly to the eye and the palate.

To stomach acids the once exotic escargots are now a collection of mixed polypeptides ready for energy release and tissue building.



During the past two years there has been a renewed interest in exotic propellants. Where does all this interest come from? Its primary source is faith, a faith which the majority of us have in the propellant chemists and the chemical industry to create rocket miracles. This faith can be touching (H_2O_4), futile (C_2H_2), or profitable (UIMH), as the case may be, both for the exotic propellant named and the chemical manufacturer in question.

Exotic propellants are probably our best path for substantial increase in power delivery. All manner of rocket power plants exist today, but if today's liquid rocket power plants are designed much beyond their present power level, we must go to higher performance propellants. The surest path for maximum increase will lie in the application of exotic propellants.

The same reasoning holds in the solid propellant field. If solid propellant power packages are to shake themselves loose from their present base at the impulse of 225 to 240, incorporation of new materials in the solid propellant matrix is probably the only solution to this problem.

Although there is no real and present reason to bring skepticism to bear on the field of exotic propellants, a few precautions are necessary. Any propellant can have hidden disadvantages which are not apparent to the over-enthusiastic. In the case of exotic plants, exotic furniture, exotic drinks and exotic places, what is irresistible at first glance proves later to be mundane and even dangerous.

Each new exotic rocket propellant, either solid or liquid, which appears on the scene should be probed cautiously by the conscientious. The exotic material must be subject to unimpeachable thermodynamic calculation to determine if it will deliver the promised power. It then should be subjected to unbiased laboratory tests to determine thermal stability, toxicity, resistance to decomposition, and the character of its combustion products.

It should be subjected to small scale motor firings to assay its general feasibility in real rocket applications. It should be thoroughly discussed with practical, down-to-earth, profit-motivated chemical firms. Can they make it? Do they want to make it? Do they have the plant to make it in? When could they make it? At what cost?

An exotic propellant must be shaken down before it can take its place with our other regular rocket propellants.★

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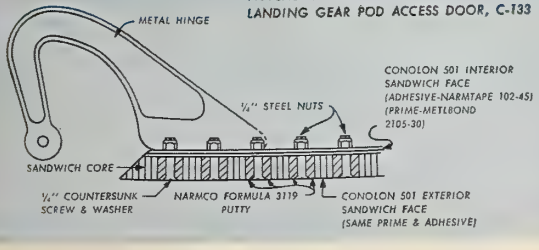
In designing access doors for landing gear pods on the mammoth C-133 Military Transport, Douglas Aircraft Company's Long Beach Division engineers faced a familiar structures problem... how best to attach critical fixtures to a sandwich component at points of high stress concentration.

To anchor hinges to the severely contoured door required 40 through-sandwich attachments; the locking mechanism required 20 blind attachments... and, in each case, it was essential that stresses be dispersed into the surrounding core. A laminated fiberglass cross-stiffener also required a medium to disperse loads into the core.

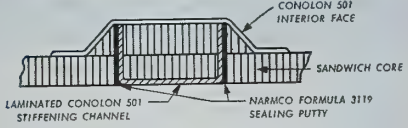
The design solution? Easy-to-handle, room temperature setting Narmco Formula Putties. Hinges are secured by nut and bolt attachments through plugs cast of Narmco putty which, in shear tests, *outlasted the sandwich structure itself!* Locking mechanisms are secured by Shur-Loks anchored in Narmco Formula Putty and cross-stiffeners are securely attached to the core with these same high-performance putties. In fact, every through-sandwich access door attachment on the C-133 utilizes strong, dependable Narmco Formula Putties!

Facing a sandwich attachment problem? Let Narmco Formula Putties help point the way to an economical, performance-tested solution.

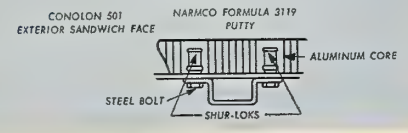
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missiles and rockets

FLUORINE . . . Tamed for Rockets



By Dr. H. R. Neumark and Dr. F. L. Holloway
General Chemical Division,
Allied Chemical and Dye Corp.

THE POTENTIALLY high performance characteristics of elemental fluorine as an oxidizer in rocket propulsion systems have generated a great deal of interest.

However, until the beginning of World War II elemental fluorine was prepared solely on a research scale. Then the development of atomic energy led to large scale production of fluorine for the manufacture of uranium hexafluoride.

Private industry recently entered the field of large scale fluorine production with the announcement by General Chemical Division, Allied Chemical & Dye Corp. of a contract with the Atomic Energy Commission to produce 5000 tons per year of uranium hexafluoride. This will require production facilities for about 1000 tons per year of elemental fluorine.

Further expansion is simply a function of demand. The plants would require no more lead time than other types of industrial facilities given similar priorities. Fluorine is no longer a laboratory curiosity. Today it is a commercial chemical which can be produced by industry in large tonnages just as liquid oxygen, hydrogen peroxide, nitric acid, or other oxidizers.

Until this year, the shipping regulations for fluorine limited its use. ICC regulations formerly restricted shipment of the gas to six pounds of fluorine in a 200-pound cylinder under 400 pounds pressure. The uneconomical weight ratio of 1 pound of gas to 33 pounds of container virtually ruled out shipment and use in large tonnage applications. Now, however, General Chemical's development and practical demonstration of an ICC licensed tank system, which permits bulk storage and shipment of liquid fluorine, has materially changed the picture.

The U.S., Canada and Mexico have ample reserves of fluorspar to take care of any emergency military requirement, in addition to an expanding civilian market for flourine-based products. To quote from the testimony of Mr. Josephson, Chief of Construction and Chemical Materials Branch of the U.S. Bureau of Mines, before the Senate Committee on Strategic Minerals, February, 1954:

"Fluorspar reserves containing 35% or more calcium fluoride would include nearly all the known deposits that are workable under present economic and technological conditions. Reserves of domestic ore containing more than 35% calcium fluoride are estimated by the U.S. Geological Survey to total 15,000,000 net tons, not considering development of latent reserves.

"If reserves of Mexico and Canada are added to those of U.S., the total ore containing 35% CaF_2 is estimated to be 23,000,000 N. T. An additional 500,000 N. T. are estimated for other known Western Hemisphere deposits on a like basis. U.S. reserves of material containing 15-35% CaF_2 are estimated to be 20,000,000 N. T."

This means about 12 million tons reserves equivalent to acid-grade spar are equivalent to 6 million tons of fluorine. An emergency need for 100 tons of fluorine per day over a period of two years equals 70,000 tons of fluorine, or only 1.15% of our total reserves.

Selected Physical Properties of Fluorine

Chemical symbol	F_2
Molecular weight	38.00
Melting Point	−219.62°C. (−363.32°F)
Boiling Point	−188.14°C. (−306.55°F)
Heat of Vaporization at normal b.p.	1564 ± 3 cal/mol
Vapor Pressure Range: Melting point − 53.54°K to 90°K	$\text{Log } P = 7.08718 - \frac{357.258}{T} - \frac{1.3155 \times 10^{10}}{T^5}$ P= mm of Hg, T = °K
Entropy of Vaporization at boiling point and 1 atm	18.38 cal/mol °C
Critical Temperature	−129°C
Critical Pressure	55 atm
Liquid Density (g/cc at 81.0°K)	1.539 − 0.002
Gas Density (0°C and 760mm)	1.696g/l
Viscosity of Liquid (80.9°K)	2.75 centipoises
Viscosity of Vapor (°C and 1 atm)	218 micropoises
Thermal Conductivity (gas, 0°C and 1 atm)	5.92×10^{-5} cal/cm degree sec
Surface Tension (liq. at 81.0°K)	14.6 dynes/cm

Chemical Properties

Fluorine is the most powerful oxidizing agent known, reacting with practically all organic and inorganic substances. The heats of reaction are always high and most reactions take place with ignition.

The few exceptions are the inert gases, metal fluorides in their highest valence state, and highly-fluorinated organic compounds such as Teflon, Genetron* Plastic H-L, or Kel-F. Even the latter may ignite in a fluorine atmosphere if contaminated with a combustible material or if subjected to high flow velocities of fluorine.

The reaction of fluorine with most metals of construction is slow at room temperature and often results in the formation of a metal fluoride film on the surface of the metal. The characteristics and adherence of this metal fluoride film determines the resistance of the metal to fluorine.

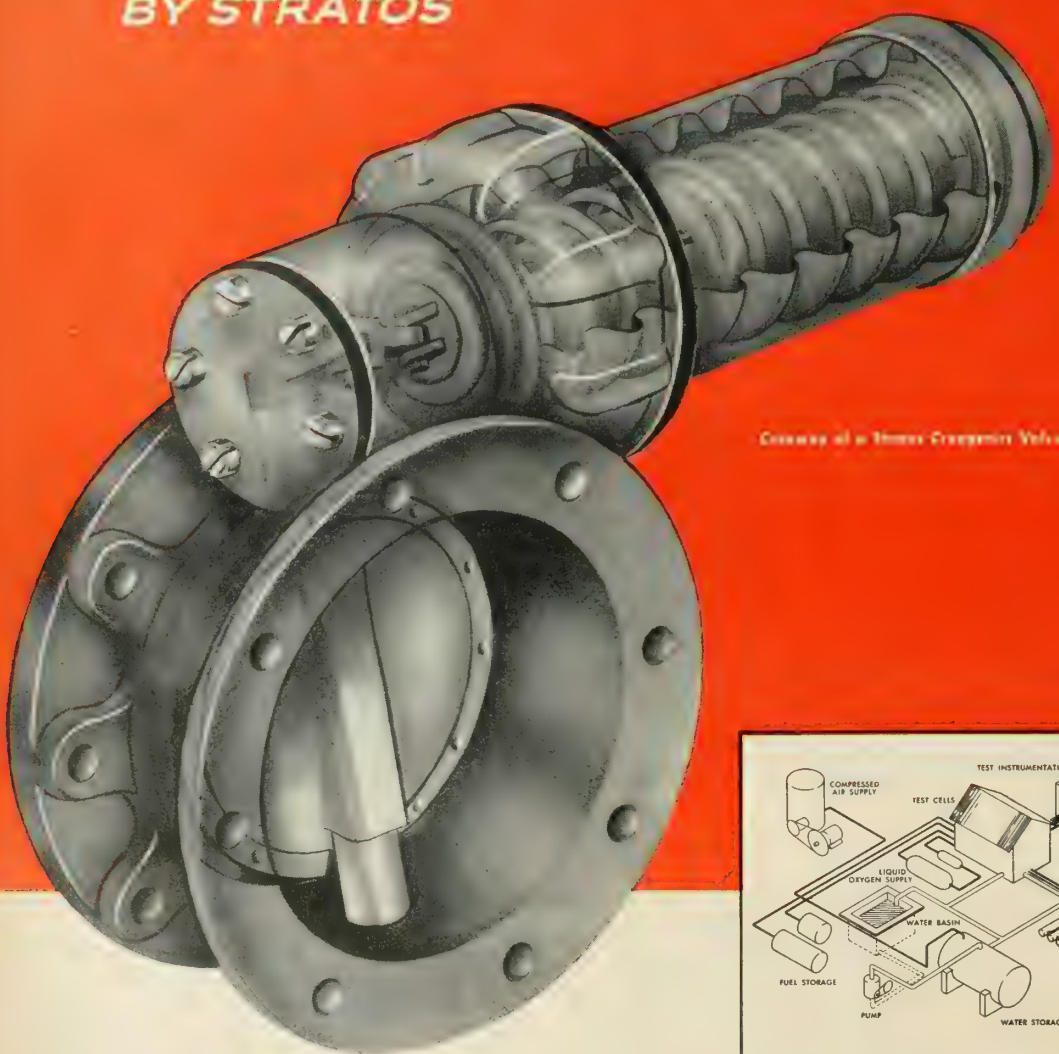
Fluorine reacts with water, forming a mixture containing principally oxygen and hydrogen fluoride plus small amounts of ozone, hydrogen peroxide and oxygen fluoride. Fluorides exhibit abnormal solubilities and high complexing power and, of all the halogens, the fluoride ion has the highest heat of hydration.

Fluorine and oxygen, gaseous or liquid, are miscible in all proportions, with no reaction taking place between

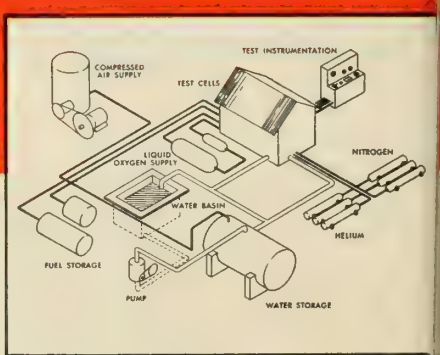
* *Reg. Trade Mark Allied Chemical & Dye Corp.*

CRYOGENICS VALVES AND PUMPS

BY STRATOS



Cutaway of a Stratos Cryogenic Valve



Schematic of the new Cryogenics Test Facility at Stratos Western Branch

With the facilities and experience to meet the growing requirements of cryogenics, Stratos is at work on a number of interesting projects in the low temperature field. Besides a basic background in the aircraft accessories field, Stratos engineering department includes specialists in cryogenics—men who have broad experience with gases at very low temperatures and with liquefied gases.

Among the cryogenic facilities at Stratos is a test installation recently completed at the Western Branch plant Manhattan Beach, Calif. This facility can test valves up to 12" diameter and achieve flow rates above 11,000 gpm.

Inquiries on valves, pumps, controls and systems are invited.

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them either at ordinary or very low temperatures.

Materials for Handling Gaseous and Liquid Fluorine

Most common metals and alloys such as nickel monel, steel, stainless steel, brass, copper, aluminum and magnesium are quite satisfactory for handling fluorine at room temperature. At elevated temperatures, the use of nickel and its alloys and stainless steel is preferable. Monel proves to be the most satisfactory metal for all-around applications at low and high temperatures.

Safe Handling of Fluorine

Fluorine can be handled without undue hazards if proper precautions are taken. In order to minimize the risks involved, the following measures should be observed:

1) In handling fluorine under pressure, remote-controlled valves should be used, preferably those operated by manually actuated extension handles passing through suitable barricades.

2) Double valving should be employed in all cases where large quantities of fluorine are being handled such as with manifold cylinders or liquid fluorine tanks. Double valving is also recommended for pressure reduction of high pressure fluorine cylinders.

3) Any equipment to be used for fluorine service should first be thoroughly cleaned, degreased and dried, then treated with fluorine gas so that any impurities may be reacted without the simultaneous ignition of the equipment.

4) Clean Neoprene gloves must be worn when handling equipment containing or contaminated with fluorine. This precaution not only affords protection against fluorine but also against hydrofluoric acid which may be formed by escaping fluorine reacting with moisture in the air. Neoprene coats and boots may be worn to afford overall body protection for short intervals of contact with low-pressure fluorine or splashes of liquid fluorine. All such protective clothing should be designed and used, however, in such a way that it can be shed easily and quickly.

5) Safety glasses should be worn at all times. Metal frames are preferable to plastic which are a fire hazard. Face shields should be equipped with clear Kel-F or Genetron HI Plastic.

In addition to these special safety measures important for the safe handling of fluorine, common sense safety precautions necessary for the handling of any toxic or reactive material should be followed.

Barricade, Remote Control Systems

Barricade systems will vary widely depending on the buildings available. In general, the function of the barricade wall is to dissipate and prevent the breakthrough of any flame and/or flow of molten metal which could issue from any part of a system containing fluorine under pressure. Quarter-inch steel plate, brick or concrete walls are adequate for cylinder amounts of fluorine (nominally six pounds).

Remote control can be achieved by a wide variety of conventional devices. A common means of opening and closing cylinders is through a right-angled transmission of torque along supported rods by means of a beveled gear arrangement. Devices using universal joints can frequently be used to advantage. Needle valves can usually be positioned so that single straight rod manipulators can be used.

Materials for Fluorine Service

	Gaseous Service	*Liquid Service*
(1) Lines and Fittings	Nickel, Monel, Copper Brass Stainless steel 304, 347 Aluminum 17, 24, 52, 61 Mild steel (low pressure)	Monel Stainless steel 304, 347 Copper Aluminum 17, 24, 52
(2) Storage Tanks	Stainless steel 304, 347 Aluminum 61 Mild steel (low pressure)	Monel Stainless steel 304, 347 Aluminum 61
(3) Valve Bodies	Stainless steel 304 Bronze, brass	Monel Stainless steel 304 Bronze
(4) Valve Seats	Copper Aluminum 2S Brass	Copper Aluminum 2S
(5) Valve Plugs	Stainless steel 304, 347 Monel	Stainless steel 304, 347 Monel
(6) Valve Packing	Copper braid backed with Tetrafluoroethylene polymer	Tetrafluoroethylene polymer
(7) Valve Bellows	Stainless steel 347 Monel	Stainless steel 347 Monel
(8) Gaskets	Aluminum 2S, Tin, Copper Tetrafluoroethylene polymer Lead Red rubber (< 5 psig)	Aluminum 2S Copper

Possible Fluorine Oxidizers

CHLORINE TRIFLUORIDE—ClF_3

Molecular Weight	92.46
Melting Point	−76.32°C
Boiling Point	11.75°C
Critical Temp.	153.5°C
Liq. Dens. (8/cc at 0°C)	1.885

BROMINE PENTAFLUORIDE—BrF_5

Molecular Weight	174.92
Melting Point	−62.5°C
Boiling Point	40.3°C
Critical Temp.	ca. 197°C
Liq. Dens. (g/cc at 1°C)	2.547

OXYGEN FLUORIDE—OF_2

Molecular Weight	54
Boiling Point	−144.8°C
Critical Temp.	−55.6°C
Liq. Dens. (g/cc at B. P.)	1.496

These compounds, like fluorine itself, are thermodynamically stable and exhibit an indefinitely long storage life.

Decontamination Procedures

Any equipment that has contained fluorine must be thoroughly purged with a dry inert gas such as nitrogen and evacuated prior to opening or refilling unless the system is used exclusively for fluorine service. A soda lime tower followed by a drier should be included in the vacuum line to remove trace amounts of fluorine in order to protect the vacuum pump.

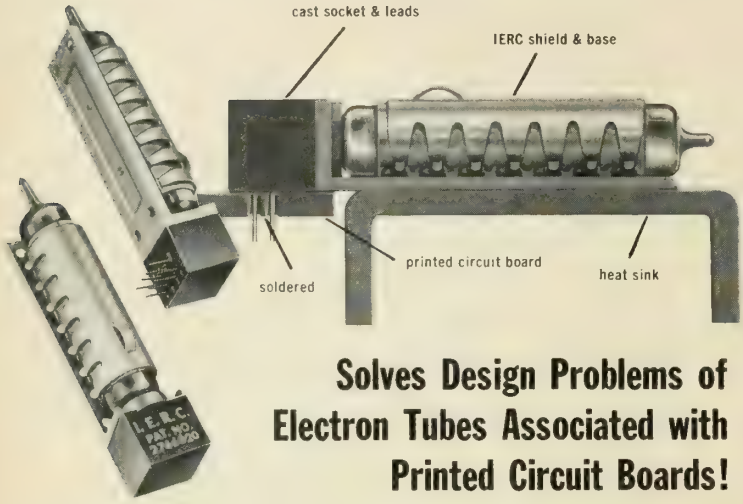
If large quantities of fluorine are to be purged, the disposal system should include a fluorine-hydrocarbon-air burner, scrubber and stack to prevent any exit hazards.

Liquid fluorine spillages should be neutralized with sodium bicarbonate. Dry chemical type fire extinguishers employing bicarbonate well-suited for this purpose. This material not only neutralizes the fluorine, but also assists in extinguishing any secondary fires caused by the reaction of fluorine with combustible material.

Packaging and Shipping

Gaseous fluorine is packaged and shipped in returnable ICC seamless high pressure cylinders #3AA-2400; these are 10 5/8" outside diameter and 55½" long without the valves. They are equipped with Chlorine Institute Valves having a ¾" male pipe thread cylinder connection and a left hand

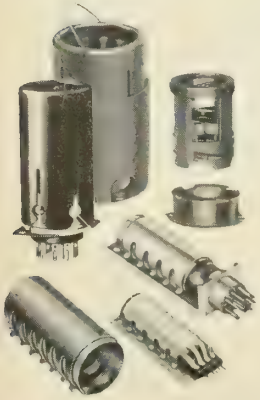
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outlet thread with a nominal diameter of 1.030". The cylinder tare weight is approximately 195 lbs.; net weight is six lbs. The gas is shipped under 400 psig pressure.

Tonnage quantities of liquid fluorine are available in tank trucks, under a special ICC permit issued to General Chemical Division, Allied Chemical & Dye Corp., authorizing shipment of the product in cargo tanks designed in accordance with company specifications.

The tank system developed for storage and shipment of liquid fluorine is basically very simple. However, it required more than two years of research and development to perfect a system which did not involve any moving parts or mechanical refrigeration.

The tank system consists of three horizontal tanks, one inside the other. The innermost tank contains fluorine, which is kept in a liquid state by liquid nitrogen in the second tank. The space between the second and third tank serves as an insulating shield for the nitrogen. It is filled with pearlite or santocel and evacuated.

The workability of this design principle is based on the low boiling point of liquid nitrogen (—320°F) which is 14° below the boiling point of liquid fluorine (—306°F). This relatively small temperature difference permits keeping the fluorine liquid under a slight vacuum in an entirely loss-free system.

As long as there is liquid nitrogen in the second tank, there is no possibility of a pressure build-up in the fluorine tank. The insulation of the liquid nitrogen tank is so efficient that nitrogen losses are maintained at a very low level. No replacement of the coolant is required for a period of several weeks. The tank system is designed to be used either as stationary storage or as a bulk shipping container when mounted on a trailer transport chassis. It is also designed to be mounted on a railroad car.

Every conceivable safeguard has been provided to assure safe filling, storage, transportation and discharge of the tank system. In order to prevent discharging liquid fluorine in the case of accidental rupture of a fluorine line, each entry into the product tank is made through the top.

Double valving is provided for both gas and liquid fluorine service in order to prevent leakage into or from the tank. The discharge of the liquid fluorine can be either carried out by standard practice of pressurizing the tank with helium or through a pressure build-up coil which would pass warm nitrogen through a vaporizing coil immersed in liquid fluorine. The helium pressure discharge method is considered simpler and considerably faster.

Liquid Rocket Engine Control

By Rudolf H. Reichel

Bell Aircraft Corp.

IN RECENT YEARS the development of large liquid rocket powerplants has followed a path similar to that of reciprocating engines, turbojets, and ramjets. Problems that were at first rather limited have increased in number and complexity leading to a more complicated engine configuration. The improvement of performance has led from simple adjustment and calibration methods to the application of control engineering philosophy. This trend has been primarily influenced by the following:

(1) Maintaining or varying the thrust vector and the combustion chamber pressure, according to a predetermined characteristic.
(2) Maintaining the propellant mixture ratio (oxidizer weight/-fuel weight).
(3) Maintaining the dynamic stability of the propellant feed system as well as the stability of the combustion process.
(4) Maintaining or varying major parameters according to a program such as combustion chamber pressure and mixture ratio for static firing test purposes.
(5) Compensation of transient or steady state errors resulting from manufacturing tolerances.
(6) Simplification of operation of the powerplant.

For airborne purposes, two basic parameters, mixture ratio and thrust can be automatically controlled.

Mixture Ratio Control

Automatic control of the mixture ratio is required in order to obtain a maximum cut-off velocity as the criterion for rocket performance. Its exact observance during the burning time will guarantee maintaining the optimum specific impulse and the complete emptying of both propellant tanks. With this a decrease of burning time as well as an increase of the total rocket mass at cut-off, is avoided.

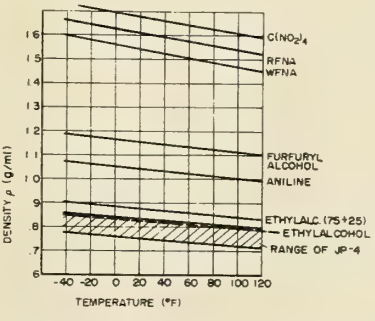
The mixture ratio can be affected by several influences. Considering some different rocket propellant combinations as presented in Fig. 1, the density characteristics of fuels run approximately parallel to each other within a usual operational temperature range between —40°F and +120°F, as do the characteristics of oxidizers. However, the slopes of the two propellant groups are different. Therefore, a change in temperatures can lead to a noticeable deviation from the design point. Further alteration of the mixture ratio is possible by incorrect propellant weight flow rates due to incorrect pump characteristics or manufacturing tolerances of the various components. Finally, because of the effect of the missile acceleration on the propellant columns of different height and density, a deviation from the mixture ratio set point may also be expected.

A suitable control system which will consider these influences is represented in Fig. 2. The basic method is to measure oxidizer and fuel flow rates and to compare their ratio with the set value. Any deviation causes a control command by which the control valve will be operated until this deviation becomes a minimum. The control valve can be installed either in the oxidizer or the fuel side. For automatic control purposes, continuous or discontinuous control systems can be used.

For the *Viking* high altitude rocket which has a vertical trajectory during the burning time, an automatic mixture ratio control system was developed with the differential pressure measurement of the propellant columns in the tanks, Fig. 3.

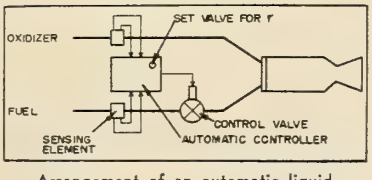
In order to demonstrate the importance of the mixture ratio control with respect to rocket performance, the ballistic single-stage rocket corresponding to Table 1 may be taken for comparison purposes. The cut-off velocity value is based upon a vertical and drag free trajectory. It is obvious that design parameters can be maintained only

Figure 1



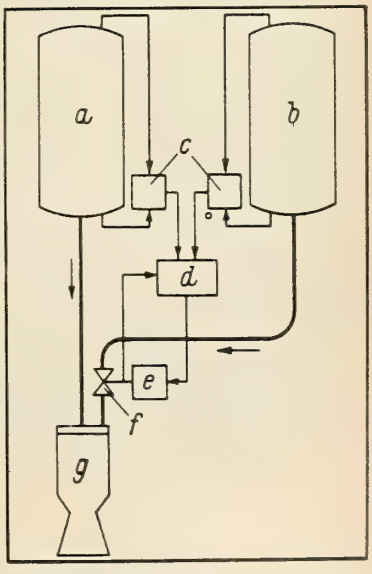
Specific gravity of some typical rocket propellant components vs. temperature

Figure 2



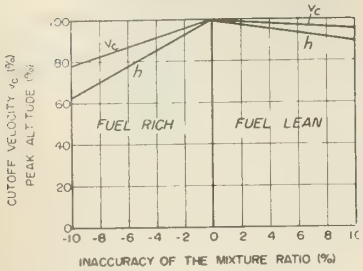
Arrangement of an automatic liquid rocket mixture ratio control system.

Figure 3



Mixture ratio control system or the sounding rocket VIKING. (a) oxidizer tank (b) fuel tank (c) differential pressure sensor (d) mixture radio controller (e) actuator (f) control valve (g) combustion chamber.

Figure 4



Loss of cut-off velocity and peak altitude, respectively, due to the inaccuracy of the mixture ratio using the propellant combination $C(NO_2)_4$/JP-4.

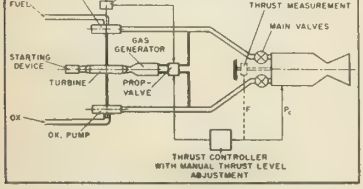
when the powerplant is accurately controlled. Fig. 4 shows the variation of the cut-off velocity v_c and the obtained peak altitude h, with deviation from the mixture ratio design value. The predominating influence for fuel rich combustion is easily explained by the high weight portion of the oxidizer. With respect to the cut-off velocity we find a diminution of about 5 per cent if the mixture ratio is only 2 per cent fuel rich which corresponds to a loss of 8 per cent of peak altitude.

In order to get a better idea of how missile acceleration affects the mixture ratio, the above-mentioned rocket can be taken as an example. In this case the predetermined mixture ratio varies from 4.52 to 4.9 under launching conditions, attaining 4.2 at cut-off. This corresponds to 9 per cent fuel lean and 7 per cent fuel rich, respectively. Such alterations of the mixture ratio cannot be accepted for large vehicles.

Thrust Control

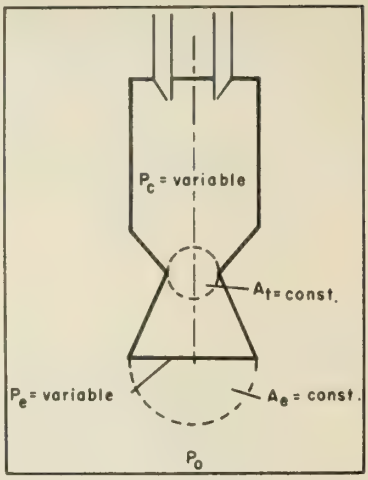
The importance of automatic thrust control depends on the required performance output characteristic of the rocket engine. In ballistic rockets, thrust will either be controlled to meet a specified acceleration requirement, or a constant thrust output will be maintained. However, the latter operating technique gives the best possible conversion of the propellants into rocket energy only if a drag free flight path

Figure 7



Thrust control system of a bi-propellant pump-fed powerplant with gas generator control for thrust level adjustment with the chamber pressure P_c as the control variable (dashed line: using thrust F as the control variable).

Figure 5

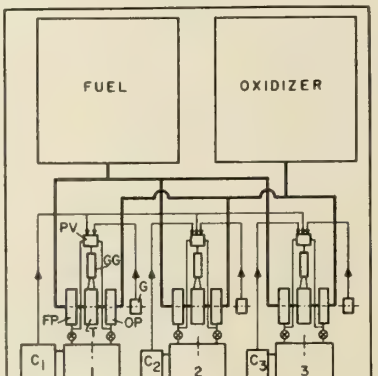


Parameters of a fixed expansion nozzle.

is assumed. Therefore, this operating restriction can be applied only for the upper stages of multiple-stage rockets. For all other cases the aerodynamic drag requires an optimum thrust programming in order to get highest possible cut-off velocity.

With respect to supersonic winged missile applications, the requirements of optimum thrust programing are similar. In many cases the propellant-wasting climbing phase will also be eliminated by launching from another ship. After release, the missile will then be propelled either by a quasi-

Figure 8



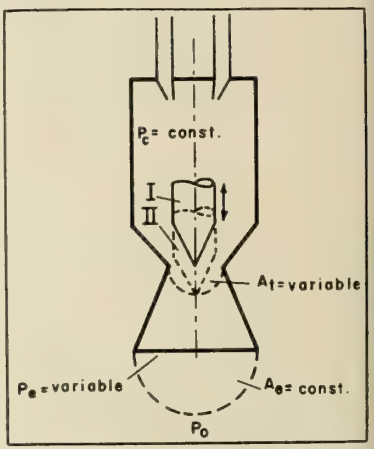
High thrust powerplant applying three combined rocket units. The master controller C_1 of unit I mixes the signals received from the other controllers C_2 and C_3 and compensates for the deviation according to the thrust set valve. Separate governor control loops are required to maintain stable conditions during starting transient. (PV = prop. valve; GG = gas generator; T = turbine; FP = fuel pump; OP = oxidizer pump; G = governor.)

constant thrust or the flight path will consist of a primary high thrust booth phase followed by an optimized lower thrust level cruising phase.

If a fixed expansion nozzle is used, Fig. 5, any off-design operation means a decrease of the specific impulse. For control purposes, the nozzle has to be designed so that with decreasing chamber pressure due to the throttling of the flow rate, shock conditions do not develop in the operating range. This occurs when the exit pressure becomes less than about 0.4 of the ambient pressure.

With a common injector, a decrease in injection differential pressure tends toward decreasing system stability even at a constant mixture ratio. This

Figure 6



Parameters of a variable expansion nozzle.

is due to the alteration of the injection flow pattern and the efficiency loss in propellant preparation for combustion. The use of several independently controlled injector groups may solve this.

With a variable throat area, Fig. 6, the operating conditions correspond to the fixed nozzle design at full thrust, i.e., when the throat plug is in position 1. For maximum throttling position 2, the limitation of the expansion nozzle area ratio is similarly affected by the critical pressure ratio due to the shock criterion. In order to control the engine, the throat plug position must be varied to maintain constant combustion chamber pressure with corresponding charge in the propellant flow rate.

The major design problem involved here is the high rate of heat transfer to this complex throat area control device. Similar to the fixed expansion nozzle design, heat transfer problems for the combustion chamber walls may also arise due to the decreasing propellant flow rate at lower thrust level.

The control procedure for a pres



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Propellant chemists and thermodynamic engineers seeking an oxidant uniquely suited to a wide range of rocket operating requirements find that Mixed Oxides offer these outstanding advantages:

Versatility — provides high specific impulse with many rocket fuels, including Triethyl-Trithiophosphate, Methyl Alcohol, 50% Ammonia and 50% Methyl Alcohol, 63% Triethylamine and 37% Orthotoluidine, Turpentine, Ammonia and Ethylene Oxides • **Freezing Point** — as low as —100°F, depending upon mixture • **Density** — compares favorably with other oxidants • **Easy Handling** — can be shipped, piped, stored in ordinary carbon steel • **High Stability** — non-corrosive, can be stored indefinitely in rockets maintained "at ready."

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Oxidant for liquid rocket propellants

Molecular weight	92.02
Boiling Point	21°C
Freezing Point	—11.3°C
Latent Heat of Vaporization	99 cal/gm @ 21°C
Critical Temp.	158°C
Critical Pressure	99 atm
Specific Heat of Liquid	0.36 cal/gm —10 to 20°C
Density of Liquid	1.45 at 20°C
Density of Gas	3.3 gm/liter 21°C, at 1 atm
Vapor Pressure	2 atm at 35°C

Photo courtesy of Rocketdyne, a Division of North American Aviation, Inc.

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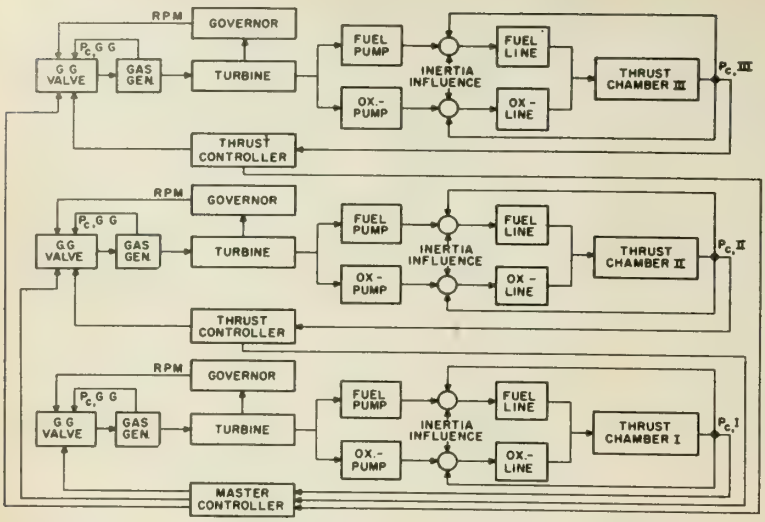
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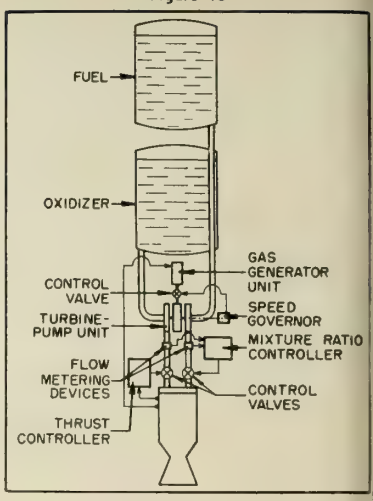
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Figure 9



Block-diagram of the high thrust powerplant according to Fig. 8 with several "internal" loop actions and cross-connections. Probable mixture ratio control is disregarded.

Figure 10



Rocket powerplant with turbine/-pump-unit including automatic thrust and mixture ratio control.

surized system using a fixed expansion nozzle motor can be performed by control valves arranged in the main propellant line. In case of more complex powerplants like those using a turbine-pump system, the propellant flow rate variation can also be achieved by automatic control of the turbine speed and the pump head, respectively, Fig. 7. In this case the combustion chamber pressure is the control variable. This method has this advantage: Any alteration of the mixture ratio will be limited due to the mutual dependance of both pump characteristics on speed. To compensate for the thrust increase due to the decreasing ambient pressure with altitude, the atmospheric pressure can be applied as an auxiliary control variable. This can be considered directly when the thrust force itself is used as a control variable (dashed line). For special requirements, it is possible to take the magnitude of missile acceleration as a control variable.

The automatic control system has to avoid any excess of turbine speed overshoot, say more than 5 per cent, and has to stabilize the engine operation at any dictated thrust level. It is obvious that these requirements need a close knowledge of the various parameters involved.

For high performance requirements multiple engine powerplants can be expected. Here, the thrust chambers will be arranged around a center line. Exact thrust control of any one chamber with respect to the others is required to avoid unsymmetrical thrust forces. In Fig. 8 such a high thrust engine unit applying three rocket motors is presented schematically. The extreme complexity of such a propulsion system can be seen by its block diagram, Fig. 9, disregarding the automatic control of the mixture ratio.

Mixture Ratio and Thrust Control

Considering a powerplant, Fig. 10, from the control engineering standpoint, several closed loops can be recognized which represent a dynamically complex system with correlative influences due to the cross-connections. Fig. 11. The thrust here is controlled by the chamber pressure, the mixture ratio by the fuel flow variation, and the gas generator system which is supposed to drive the gas turbine, by the turbine speed. Together with the feedback action of the chamber pressure, six closed loops result. The various pressure controllers, as usually arranged within the engine system, represent minor control loops which in case of instability act as disturbances on the major loops.

Combustion Stability Control

One of the major problems of rocket development is the dynamic stability of the combustion process even when an automatic control system is applied. Several investigators have pointed out that not only the configura-

Figure 11

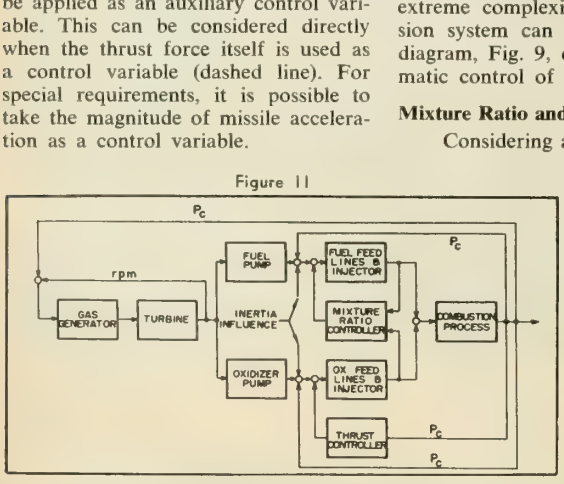


Figure 12

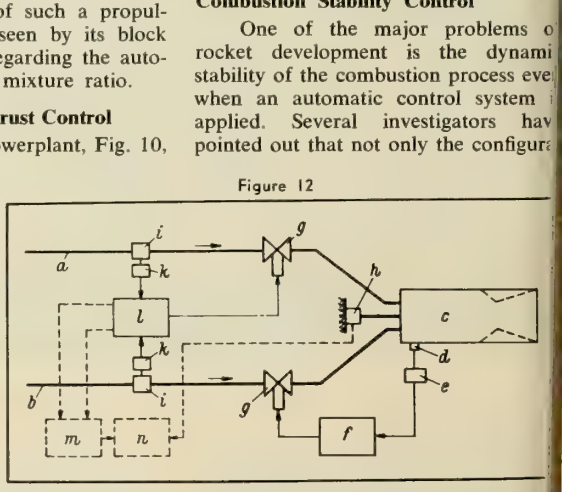


Fig. 11. Block-diagram of the rocket powerplant according to Fig. 10 with six closed-loop actions. Fig. 12. Experimental arrangement f automatic control of combustion chamber pressure P_c and mixture ratio. (a) oxidizer (b) fuel (c) combustion chamber (d) pressure pick (e) transmitter (f) pressure control unit (g) control valves (h) thrust measurement device (i) sensing elements (k) transmitter (l) mixtu ratio controller (m) computer for the determination of the mass flow rate (n) computer for the determination of the exhaust veloci



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Electrical specifications of the Console Recording Systems include a basic sensitivity of either .01 volt/chart division (5490 types) or 0.1 volt/chart division (5495 types); linearity of 1%; drift less than 1/2 chart division/hour (5490), less than 1/20 chart division/hour (5495); flat frequency response to 20 cps, down 3 db at 60 cps for all amplitudes to 5 cm peak; either single-ended or push-pull input signals of 5 meg. impedance (each input lead to ground).

A useful companion instrument is the new Sanborn Model 183 Programmer, designed to provide a connecting link between an analog computer and the Console Recording System. Shown mounted at the top rear of the Console, the Programmer operates the Console in the following automatic sequence: turns recorder drive on—feeds calibration signals to all channels—reads initial DC levels of computer—closes contacts to start computer problem—records computer output for a preset chart length—turns off recorder drive and resets itself for another cycle.

Further technical data, prices and delivery information—on the 5490/5495 Console Recording Systems and two- to eight-channel 5475/5480 Systems are available on request from your Sanborn Sales-Engineering Representative or the Industrial Division in Waltham.

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Initial weight	53,600 lb
Empty weight	9,500 lb
Mass ratio	5.64
Propellant weight	44,100 lb
Set value for mixture ratio	4.52
Thrust	132,500 lb
Specific impulse	210 lb-sec/lb
Cut-off velocity	9,460 ft/sec
Peak altitude	303 miles
Burning time	73 sec

Table I—Data for a single-stage ballistic rocket using tetranitromethane as the oxidizer and JP-4 as the fuel.

tion of the combustion chamber and the injector, the chemical and physical properties of the propellants, but also the effect of dead time and non-linearity within the process, the stiffness of the structure including propellant tanks and lines, the propellant compressibility and aerodynamic forces, represent a complex system affecting the combustion stability.

Up to the present, the low and high frequency combustion instability problem must be handled more or less in an empirical manner although there are several theoretical papers which propose methods for the automatic control of low-frequency combustion instability. These control methods are not yet of any practical use.

Automatic Control Methods for Static Firing Test Purposes

It is an essential task of the static firing test to check design parameters and to examine propellant combinations. Common methods to determine the plot of specific impulse I_{sp} vs. mixture ratio step by step within a test series using manual control procedure, include some difficulties, especially when optimum conditions (e.g., constant chamber pressure) should be maintained. By application of automatic control methods, the function I_{sp}=f (mixture ratio) can be determined within only one run. This method results in saving of time and propellant expense, and improves the accuracy especially when oxidizers with a corrosive effect are used.

Using an automatically controlled arrangement according to Fig. 12, the following problems can be solved:

(1) I_{sp} vs. mixture ratio with the chamber pressure as the parameter, Fig. 13, solid lines.

(2) I_{sp} vs. combustion chamber pressure with the mixture ratio as the parameter, Fig. 13, dashed lines.

(3) Combustion chamber pressure and mixture ratio are held constant. This method corresponds to an acceptance test.

The last step would be to evaluate the test values by means of computers and to record the results even as the test run is being carried out. Besides the usual data such as tank pressures, thrust, propellant flow rates, and combustion chamber pressure, other values can then also be evaluated immediately after the run. To perform all required calculations computers are needed as plotted by dashed lines, Fig. 12.

The Experimental Investigation of The Dynamic Stability

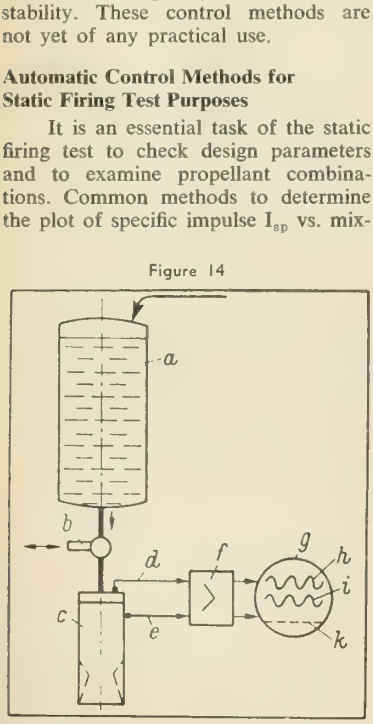
Theoretical papers try to represent the dynamic system, e.g., Figs. 10 and 11, by means of linear differential equations of the closed-loop or by the transfer function. However, for practical purposes there are limitations since the theoretical representation of the dynamic system and therefore the information on coefficients and disturbances, is hard to realize at the design stage.

Besides the experimental dynamic stability investigation of pressure regulators, turbine-RPM-governors, or any other control arrangements known in common control engineering, the investigation of the complete propulsion system is of a special interest. To consider a simple example of overall stability, a mono-propellant pressurized system is represented in Fig. 14. The investigation has to be performed under actual conditions with installed combustion chamber, lines, values, propellant tank, etc. Because there is an "internal" feedback action here due to the combustion chamber pressure, it is not possible to get open-loop conditions for investigation purposes. The only possibility is to feed the propellant feed system or even the combustion chamber with a harmonic disturbance. As an example we can disturb the propellant flow rate by means of a piston pulser (input variable) and record the chamber pressure response (output variable) depending on the frequency, in order to get the stability margin. Unfortunately, up to the present time it is very difficult to measure flow rate fluctuations reliably. For that reason we only can measure the injection pressure and determine whether there is any critical amplitude ratio (chamber pressure injection pressure ratio) within the required operating range.

In the case of a bi-propellant rocket, this method has to be applied accordingly, however, the harmonic disturbances are to feed in such a way that any alteration of the mixture ratio will not influence the overall stability.

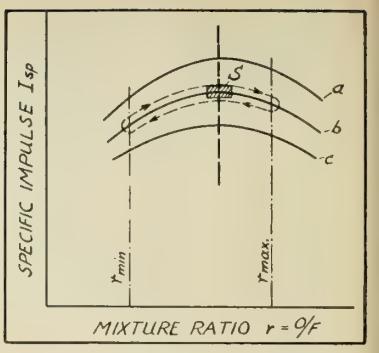
As another example a thrust and mixture ratio control is considered. The dynamic overall stability can be determined when the thrust control loop as well as the mixture ratio control loop are to be cut and considered as open loops, points A and B, Fig. 15. The investigation then can be accomplished subsequently by feeding the loops with harmonic disturbances according to the operating conditions. ★

Figure 14



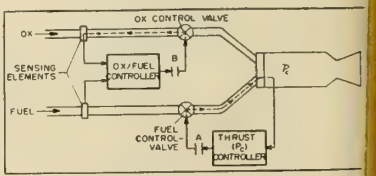
Test arrangement for the stability investigation of a mono-propellant pressurized system. (a) propellant tank (b) piston pulser to generate a harmonic disturbance (c) combustion chamber (d) injection pressure P_i (e) chamber pressure P_c (f) amplifier (g) oscillograph (h) P_i as the input variable (i) P_c as the output variable (k) time mark.

Figure 13



Automatic control of P_c = constant and mixture ratio = constant. a to c are curves of three different P_c values as parameters. S = area covers the tolerance for an acceptance test.

Figure 15



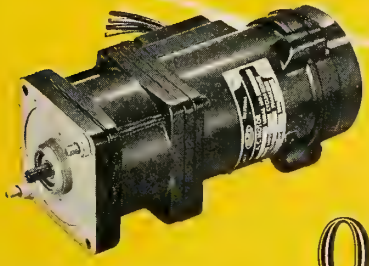
Test arrangement for the stability investigation of a bi-propellant rocket powerplant with a thrust and mixture ratio control loop. At A and B the loops can be cut for investigation purposes.

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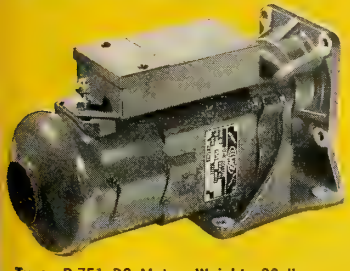
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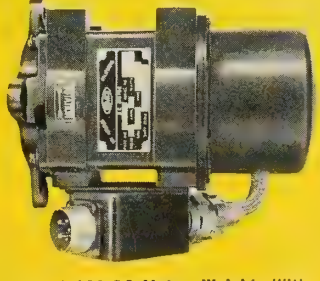


Type: D-751 DC Motor. **Weight:** 20 lbs. **Duty Cycle:** 5.2 hp at 2100 rpm (intermittent) on 26 volts DC; 3.5 hp at 2200 rpm (continuous) on 26 volts DC. **Meets Military Specification** MIL-M-8609.

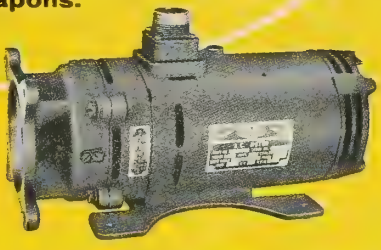


Type: D-899 400 cycle 3 phase AC Motor. **Weight:** 11.25 lbs. **Volts:** 200 volts. **Load:** 2.75 hp continuous output. **RPM:** 3140 rpm output at gear box. **Power factor:** 83%. **Overall efficiency:** 76% for entire unit. **Meets Military Specification** MIL-M-7969A (ASG).

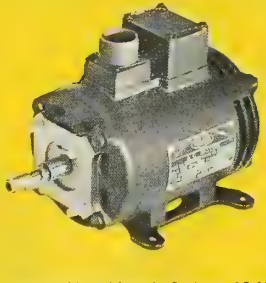
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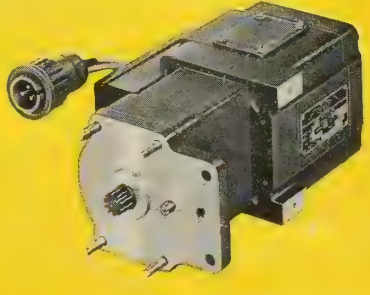
Type: D-932 DC Motor. **Weight:** With radio noise filter—13 lbs., without same—12.4 lbs. **Terminal voltage:** 27.5 DC plus or minus 1.5 volts. **Load:** From .5 hp minimum to 2.6 hp maximum. **Speed:** Continuous at 12,000 rpm, plus or minus .005%. **Speed Control:** By frequency regulator supplying control field. **Meets Military Specification** MIL-M-8609 (ASG).



Type: D-638 400 cycle AC Motor. **Weight:** 17.5 lbs. **Voltage:** 200 AC, 20 amps at 6.5 hp. **Duty cycle:** 3.0 seconds at 6.5 hp, 15.0 seconds at 1.5 hp. **Maximum capacity:** 6.5 hp. **Continuous rating:** 5 hp at 2300 rpm, 15.8 amps, 200 volts. **Meets Military Spec.** MIL-M-7969A (ASG).



Type: D-800 400 cycle 3 phase AC Motor. **Weight:** 8.75 lbs. **Voltage:** 208 volts. **Horsepower:** 2.5 hp. **Continuous Duty:** 11,300 rpm; Equipped with thermal protector. **Meets Military Specification** MIL-M-7969A (ASG).



Type: D-927 DC Motor. **Weight:** 7.25 lbs. with 2-circuit noise filter for ungrounded systems. **Weight of filter:** 1 lb. **Terminal voltage:** 27 volts, 18 amps. **Load:** 0.5 hp. **Speed:** Continuous at 9900 rpm. **Meets Military Specification** MIL-8609.

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Liquid Propellants for Manned Rocket Aircraft

By William Mitchell
Reaction Motors Inc.

THERE IS A MILITARY NEED for manned rockets. Guidance lone may never measure up to the job f bringing in the shot on a pinpointed rget. At 150 lbs. a pilot represents rtain guidance functions that all the ectronic gear in the world couldn't uplicate. The pilot could act as ver- ier guidance to rain a whole fleet of her guided missiles on particularly oscure targets.

There is also the most exciting le of all, the passenger and cargo rrying rocket. It does not seem likely at a chemical rocket will ever propel an over interplanetary distances, nor en to the moon. That seems to be a b for the nuclear rocket.

North American has announced eir forthcoming X-15 with speeds omised in excess of those achieved to- ay. The propellants for the X-15 are announced but the others employ quid oxygen and ethyl alcohol. This mbination has done yeoman service the early missiles such as the V-2 d the *Viking*. While LOX and ethyl cohol fulfill today's needs, they will not do for tomorrow's job.

The manned rocket of the future will fall into one of the three classes already mentioned: the military rocket, the commercial rocket, the research rocket.

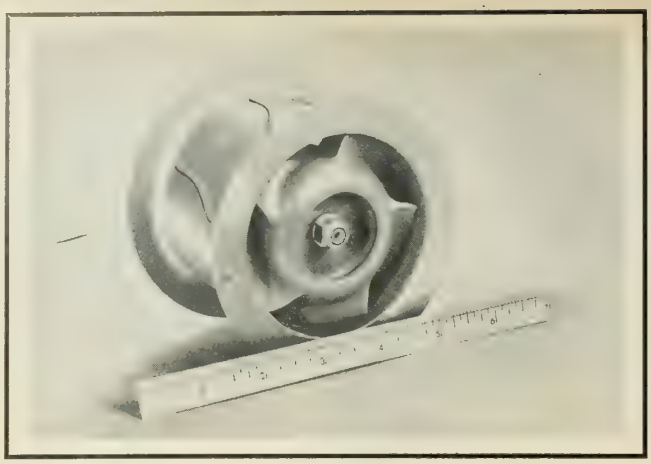
Propellant Requirements

The propellant requirements for each of these will in some ways vary from each other and from guided missiles. In most qualities the requirements of manned and unmanned rockets will be the same. The major difference between a manned and unmanned rocket is the need to return the pilot. This means some form of airfoil device to permit a glide return which results in a drag increase for a manned rocket greater than that of an equivalent impulse guided rocket.

The pilot must be protected from aerodynamic heating, so an additional cooling problem is impressed on the manned rocket. In addition, the pilot cannot withstand the same accelerations that can be tolerated by instruments, airframe and warhead. He must have oxygen, be protected from toxic leaks, and some sort of atmospheric pressure must be supplied. The hardware weight in a manned rocket will tend to be higher than is necessary for a guided rocket.

On the plus side, however, the manned rocket will require little or no guidance, although the pilot may depend to a large degree on data and instructions from electronic gear. The pilot is a reliability promoter and can correct some failures if they occur. In general, his ship should be less complicated in system concept than a guided missile.

For any rocket, manned or guided, high boiling point and low vapor pressure are desirable propellant characteristics: the propellant can act as a heat sink without boiling or requiring very high propellant pressures to remain liquid. Liquid temperatures can easily approach 300°F in supersonic dashes as a result of aerodynamic heating. On top of this—the regenerative cooling requirement of heat flux in excess of 10 BTU/sec-ft^2



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— °F —the temperature requirements of the propellants can easily be raised to 500°F. It is a natural desire on the part of the designer to reject to the propellants the heat liberated in cooling the passenger of the manned rocket. So still another heat load is added to the propellants.

The ideal property of high boiling point is even more desirable for the manned rocket than for the guided missile. In all of today's manned rockets the liquid oxygen oxidizer is a totally worthless propellant in view of the high boiling point requirement. The other half of the propellant team, ethyl alcohol, is more noted for its cooling properties and thermal stability than as an energetic fuel.

Low Freezing Point

Propellants that do not meet freezing point requirements can sometimes be rendered usable by the use of additives such as ammonium thiocyanate added to hydrazine or water to hydrogen peroxide. Usually, the use of an additive to improve one property, such as freezing point, will result in the deterioration of another desirable property. For example, while the freezing point of hydrogen peroxide can be improved by adding water, the resultant solution does not have the oxidizing power that neat peroxide enjoys. Mechanical aids can be used to overcome high freezing point such as heating blankets, blowing warm air around a propellant tank, or storage of propellants in heated areas. All of these add to the complexity of handling equipment.

The desirable property of low freezing point can be somewhat sacrificed by limiting launching operations to tailor-made installations or temperate climates. While this may be tolerated for research vehicles, it would hardly be a worth while sacrifice for fleets of military rockets and it would exact a severe logistic penalty for future commercial operations.

A low value of viscosity plus a flat viscosity vs temperature curve is desired. Low values of viscosity are necessary for the small, superspeed pumps that are being designed into missiles. Lacking temperature independence of viscosity, the rocketeer must then accept engine performance variations or else build in a complicated compensation system.

As in the case of freezing point, the designer of a manned rocket may accept a relaxation of this requirement because in the pilot he has a guidance computer that can readjust to compensate for temperature variation. The pilot may be able to adjust the trajectory or the rate of propellant flow



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The missile designer is constantly faced with a choice between high density or high impulse, rarely does he enjoy the advantage of both. Fuels usually run to densities less than 1.0 gm/cc—more often than not around 0.8 gm/cc. Oxidizers are heavier, running from around 1.14 gm/cc for liquid oxygen to 1.55 gm/cc for red fuming nitric acid and fluorine. Practically all rocket propellant systems use more pounds of oxidizer than pounds of fuel, and this is a distinct advantage in lowering tankage weight.

In the past most of the rocket chemist's attention has been devoted to rocket fuels, but in the past few years there has been a switch to more research in oxidizers. Fuels still command the lion's share of propellant R&D. Oxidizers offer a promising field for research, since most oxidizer molecules are dense, and rocket engines always operate most efficiently on the fuel rich side. It is through oxidizer research that the present bulk densities of propellant systems can be raised from the prevailing range of 1.0-1.2 gm/cc to the 1.5 gm/cc range.

High density for the manned rocket is a must or else the rocket is forever chained to sub-space flight. The silhouette must be kept small so that the rocket can be launched from a mother vehicle. Ground-launched, manned rockets require a glide vehicle for the pilot's return. The added drag of the return vehicle must be compensated by high propellant density and a subsequent lowering of drag area through compact tankage.

Present-day manned rockets utilizing LOX and ethyl alcohol are in violation of the high density principle. These rockets are very limited in flight capacity.

Nontoxic Requirements

Aviation gasoline, jet fuel, and liquid oxygen must be considered toxic, or at least dangerous propellants, by the usual methods used to determine toxicity. Beryllium, now labeled dangerously toxic from its history in the fluorescence field, is practically ignored as a fuel atom.

Meanwhile boron is the subject of a great deal of experimentation, although beryllium has at least as bright a theoretical future. Such taboos can be overcome as indicated by the rise in liquid fluorine and liquid interhalogen research as rocket oxidizers. With materials research and handling techniques constantly lessening the danger of accidents, it is not unlikely that dangerously toxic materials will be tolerated for manned rockets of the future.

Toxic propellants can be controlled through adequate containment and toxic exhaust products can be vitiated by treatment or firing in remote places.

Noncorrosive Factor

There are no "ordinary" materials capable of containing some of today's corrosive propellants. Today's rocketeer talks of stainless, inconel, aluminum, silver, nickel, monel, teflon, Kel-f, fluorlub, etc. These are now "common" materials. The program leading to the synthesis of a new propellant quite often touches off an equally large program in the synthesis of a new alloy compatible with the propellant or its combustion products.

Liquids that can propagate explosions in the liquid phase are considered unsatisfactory for any kind of rocket, since involvement of the entire propellant supply in the tanks is possible.

The field of shock sensitivity is still far too much in the realm of clairvoyance. There are many propellants moderately labelled shock sensitive that await standardization and interpretation of tests. This is one facet of propellant chemistry that is receiving a great deal of attention today. The very nature of the molecular instability is an advantage when one considers the propellant from the viewpoint of wanting high specific impulse. A definition of tolerable limits is needed.

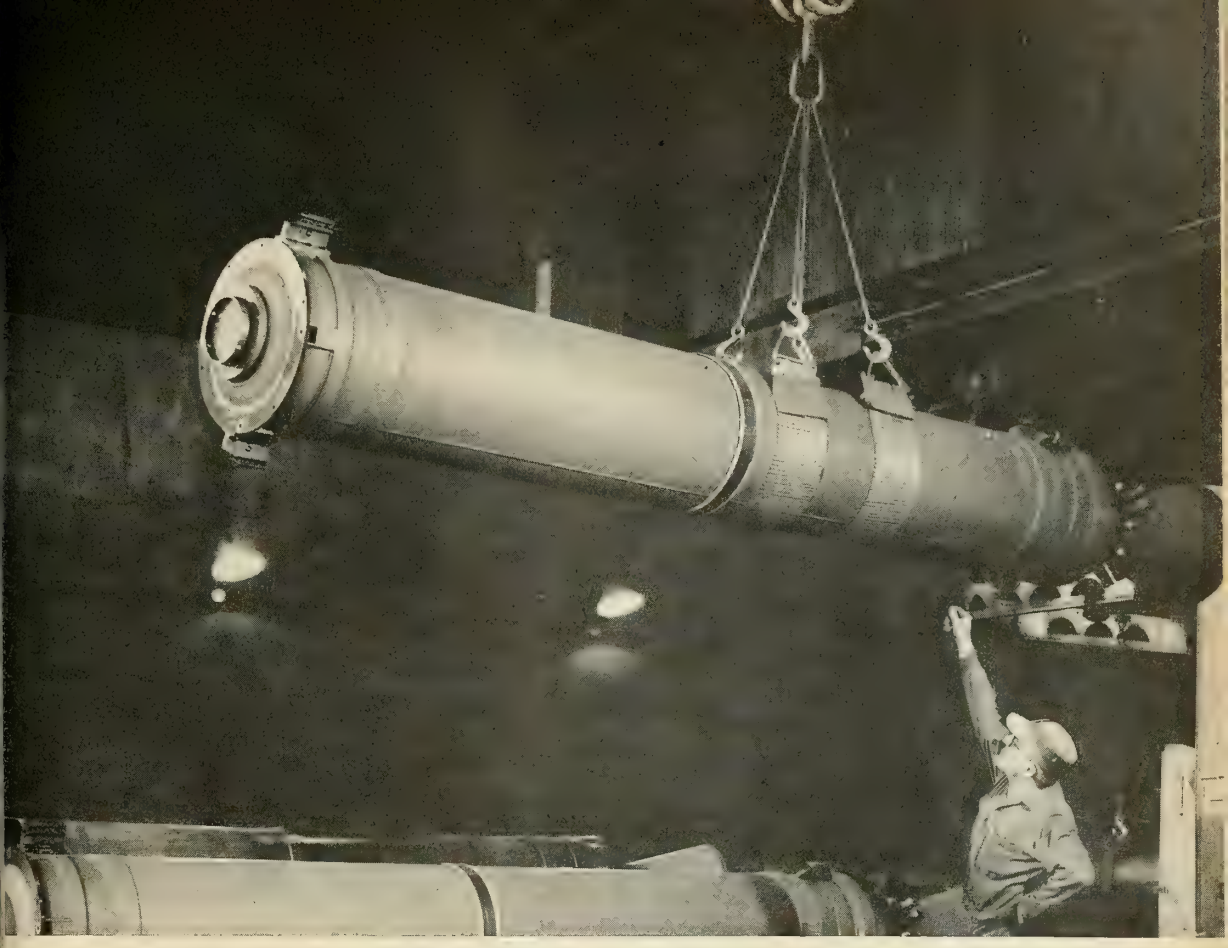
The requirements for a manned rocket are no different in this respect than for a guided rocket, unless, as in the case of corrosivity, a little extra is required.

Ease of Ignition

There is probably no area which has been more of a headache to the combustion chemist, the thrust chamber designer, and the test engineer than accomplishing safe, positive, repetitive starts and maintaining smooth combustion. Since it is impossible to predict combustion kinetics, propellants are evaluated and chambers are designed on equilibrium conditions and a number of ignorance factors commonly called "experience."

The size of the combustion chamber and the injection arrangement is usually finalized after hundreds of hot tests, some of which result in harder starts than the test chamber can stand. There are spark igniters, glow plugs, pyrotechnic squibs, hypergolic leads sequenced operations, injector face shutoff valves, splash plates, and other sundry rocket engine tricks to overcome our lack of knowledge of combustion kinetics and droplet burning. Since these problems are not likely to be solved soon, we must fall back on "experience."

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the hypergolic pair, in which the fuel and oxidizer ignite on mutual liquid contact. Hydrazine and red fuming nitric acid (RFNA) are such a typical pair. Fluorine and nearly any fuel is another pair, while hydrogen peroxide can accomplish ignition with many fuels because the exothermic decomposition of the peroxide provides temperature as well as free oxygen.

The ignition delay of a hypergolic pair must be short enough (less than 50 milliseconds, preferably less than 20) so that propellant cannot accumulate in the chamber to create an explosion.

Good ignition and combustion is a must for manned rockets.

High Specific Impulse

This is the most important property of all, for it is in the bond energies of the molecule and in the resultant combustion product that the chemical energy is converted to kinetic energy. The parameter specific impulse is usually defined as the pounds of thrust per pound per second of propellant flow or $I_{sp} = F/W = \frac{\text{lb.}}{\text{lb. 1/sec.}} = \text{sec.}$

The propellants react in the chamber to produce heat and gaseous products. The products expand through a nozzle, converting part of their heat energy to kinetic energy, and are exhausted. The specific impulse of a rocket motor depends only on the nature of the propellant, the chamber pressure and the exhaust pressure. The only properties of a propellant that affect specific impulse are empirical formula and heat of formation.

There appears to be a limit of about 400 seconds to specific impulse for chemical rockets. It is unlikely that a manned rocket will ever achieve this since this high a value will probably require high heat of formation propellants which lowers sensitivity and thermal stability.

Specific impulse is a measure of impulse per unit weight. The term density impulse has been created to represent a measure of impulse per unit volume.

$$I_{sp} = \frac{\text{impulse}}{\text{unit weight}}$$

$$\text{bulk density} = \frac{\text{unit weight}}{\text{unit volume}}$$

Therefore,

$$(I_{sp})(\text{bulk density}) = \frac{\text{impulse}}{\text{unit volume}}$$

A high density impulse is desirable in reducing silhouette for manned rockets, but not at the expense of low specific impulse coupled to a high density propellant combination. The weight of the pilot plus the special hardware and glider requirements represent a fairly heavy payload and high value of specific impulse is a must if the rocket is to be propelled very far. Therefore, the manned rocket has the same requirements as the long-range, heavy payload guided missiles, namely high specific impulse. On top of this it has the further requirement of high density to trim silhouette, so that it will fit in the mother ship necessary for launch, or, barring that, will present a low drag area for ground launched vehicles.

High Thermal Stability

If any rocket motor is to survive for very long with combustion gas temperatures of 4000 to 10,000°F, it must be cooled, or else the burning time is restricted to seconds, not minutes. The heat is usually rejected to one or both of the propellants. In a manned rocket, the extra cooling required dictates a need for thermally stable propellants.

To be thermally stable, a propellant should not decompose exothermically, or become excessively shock sensitive as temperature increases. To maintain satisfactory cooling of the rocket chamber, the propellant must stay below the critical temperature, and remain a liquid in the cooling passages without resorting to extremely high fluid pressures.

High impulse fuel usually dictates materials that are inherently sensitive due to high heats of formation, and this basic sensitivity cannot be overcome by additives. A compromise must be made between performance and sensitivity. One such compromise is the case of unsymmetrical dimethylhydrazine (ULMH) over hydrazine. Another is liquid oxygen over liquid ozone.

The requirement of high thermal stability is more necessary for the manned rocket then the unmanned rocket; however, some degree of instability must be tolerated to gain performance. There is a great need for propellant research in producing thermally stable propellants that pack performance. If none are found, manned rockets will never be much more than a dangerous research tool.

The accompanying list and table gives an approximation of the qualities of some of today's propellants.

Jet Fuel and LOX

Combustion difficulties and hard starts are known. Specific impulse is better than average but not good. Bulk densities are low. Thermal stability of the jet fuel is good and may be used as a regenerative coolant. This propellant combination would support today's manned rockets, but density, specific impulse, and combination qualities are not up to tomorrow's needs. Availability and cost will always make this combination attractive.

Ammonia and LOX

These are readily available; cost only slightly greater than jet fuel and LOX. Specific impulse is about the same. The low density of ammonia is even more of a penalty than is jet fuel. While ammonia ignition is difficult, combustion is smooth and hard starts are rare. Ammonia is a good regenerative coolant and endothermic decomposition is an advantage. Satisfactory for current needs only.

Hydrogen Peroxide and Boron Fuel

Boron fuels have been announced as a future jet fuel. Therefore, it is a reasonable assumption that they will also be among future rocket fuels. Specific impulse is moderately high. Bulk densities are good. Cooling may be a problem, but both materials may be used as coolant. Costs are apt to be moderately high. No cryogenic fluids in this system.

RFNA and Amine

Acid density is very high. Hypergolic starts and smooth combustion prevail. Cost presently is fair, and may be relatively good in the future. Specific impulse is on the low side. Availability is good. Cooling can be achieved by both fuel and oxidizer. Low impulse will limit lifetime.

Hydrazine Liquid Fluorine

This is the ultimate in today's propellants for density and impulse. It employs hypergolic ignition. Very high flame temperatures and the uselessness of fluorine as a coolant plus the marginal thermal stability of hydrazine will probably mean a third fluid as a coolant. Cost will be high, and handling will be dangerous. This is one of the few materials that measure up to tomorrow's needs from the impulse and density view.

Liquid hydrogen appears to have no place in the manned rocket field due to extremely low density. Liquid ozone is far too unstable. Normal propyl nitrate and nitromethane lack impulse and present sensitivity problems for manned rockets. Ethylene oxide also lacks impulse, but may be used as a gas generator for turbopumps and auxiliary power units.

The field of propellant chemistry must produce the high specific impulse, high density and thermally stable materials that tomorrow's manned rockets need. If not, the answer must be sought in nuclear rockets or space particle rockets, or else man will have to be content with flying up to a few hundred thousand feet and then gliding back to earth.★

NOW FROM FORD INSTRUMENT ALL-SILICON-TRANSISTORIZED EXHAUST TEMPERATURE INDICATOR



Actual size of instrument face.

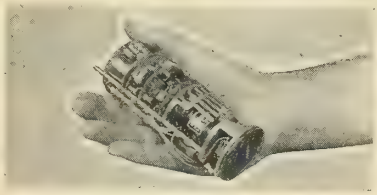
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- 2 sec. full scale response
- Wide environmental range
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- Integral power failure indicator
- No calibration required.

Developed for Navy BuAer For first time commercially available

Ford Instrument's Engine Exhaust Temperature Indicator was developed for the Navy Bureau of Aeronautics and is now available to other users. It is a self-contained unit which continuously displays temperature over a 200-1000°C range with ±5°C accuracy. Of extremely compact construction, it has less than one-third the volume and weight of comparable vacuum tube units. Silicon transistors are used throughout, enabling the ETI to withstand a wide range of ambient temperatures. Weight of the unit is only 16 oz.

High Applicability Coupled with precision measurement



Miniaturization provides a 2" diam. x 6" long self-contained unit. (Unit is shown with case removed.)



FICo's ETI is packaged in a single hermetically sealed case.

The FICo ETI is used for measuring exhaust temperature in turbo props, turbo jets—or in any other gas turbine within its range. It is a panel-mounted unit. Its high accuracy enables the pilot to closely observe engine temperature to ensure safe and efficient engine operation.

The fast response of the ETI makes it highly suitable for multiple thermocouple installations. It can be used as a monitoring unit with any number of chromel-alumel thermocouples in conjunction with a suitable switching device.

The ETI is highly applicable to laboratory flight test applications. In addition, with modification, it can be used in conjunction with airborne time-temperature recorders.

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DIMAZINE . . .

comes of age as rocket fuel

By William G. Strunk
Westvaco-Chlor-Alkalai Div.
Food Machinery and Chemical Corp.

UNLIKE THE physically refined, naturally occurring hydrocarbon fuels, Dimazine is a specific synthetic chemical compound. Because it is a pure compound, produced under controlled conditions, its physical and chemical properties are constant. It is a clear, colorless, hygroscopic liquid with a rather sharp ammoniacal or fishy odor, generally characteristic of organic amines.

Its structural formula is $(CH_3)_2NNH_2$, and its molecular weight is 60. It has a specific gravity of 0.795 at 60°F/60°F and weighs about 6.64 pounds per gallon. It boils at 146°F and freezes at —71°F. The material is reasonably volatile, having a vapor pressure at 70°F of about 120 mm, or one-sixth atmosphere.

It is miscible in all proportions with water, ethanol and most petroleum fuels.

Dimazine has a flash point of 34°F and flammability limits in air from 2.5 to 95 per cent by volume. The autoignition temperature in air is 482°F.

Dimazine reacts with carbon dioxide to form a salt. Extended exposure of it to air or other carbon dioxide-containing gases could lead to eventual precipitation of the material. Dimazine reacts slowly with oxygen or oxygen-containing gases at ambient temperatures to form several products.

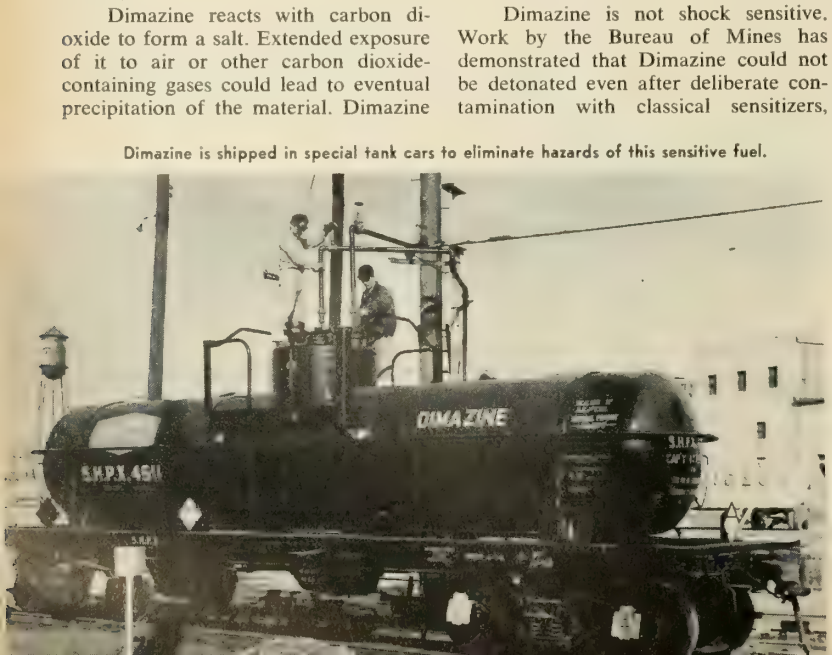
For flammability safety considerations, Dimazine is stored under nitrogen and under these conditions we have observed no formation of gums or other solids, even after sustained storage.

Range-forming work on high temperature stability has been carried out by heating small quantities of Dimazine in glass capillaries to successively higher temperatures. Essentially no decomposition was observed below the critical temperature of 482°F, or during thirty minutes at 550°F.

Some carbonization appeared at 700-800°F accompanied by a decrease in liquid volume upon cooling at ambient temperatures. Inclusion of nickel and stainless steel specimens in the capillary containers had no obvious effects. Further work investigating the high-temperature characteristics of Dimazine is under way. Dimazine mixtures have been used as regenerative coolants in rocket motors.

Dimazine is not shock sensitive. Work by the Bureau of Mines has demonstrated that Dimazine could not be detonated even after deliberate contamination with classical sensitizers, such as rust, copper and magnesium turnings and aluminum powder.

Dimazine is shipped in special tank cars to eliminate hazards of this sensitive fuel.



Materials of Construction

METALS. No known limitation exists on the use of nickel, Monel or Types 303, 304, 316, 321 and 347 stainless steel in contact with Dimazine. Aluminum and its alloys and magnesium (Dow metal 302) are good. Commercial Dimazine does not attack aluminum even with several per cent added water; however, some attack of aluminum has been observed by dilute aqueous solutions of Dimazine.

It should be noted that Dimazine typically contains about 0.1 per cent water. Easy Flow #45[1] silver solder appears satisfactory for use in brazing applications associated with Dimazine. Copper and high-copper alloys should be tested under proposed use conditions because we have observed corrosion of copper by refluxing Dimazine, although brass was essentially inert under these conditions.

Elastomers

Compatibility of Dimazine with a large number of non-metallic materials of construction has been checked. The best materials include Teflon[2], unplasticized Kel-F[3], polyethylene, Garlock gasket 900[4], Hydropol rubber[5], and graphite, but even less resistant elastomers are being used successfully in certain applications. Promising results are being obtained in a program developing fuel cells and bladders for Dimazine and Dimazine blends.

O-RINGS. Westvaco manufacturing facilities have used Garlock 90 gaskets with very good service. Polyethylene and Teflon have proven excellent as gaskets for shipping containers.

HOSE. The type of hose recommended will depend on the specific service intended. Flexible stainless steel and polyethylene hoses have been used for some applications. In view of the inertness of Teflon and unplasticized Kel-F, hoses properly fabricated of these materials would be serviceable

PUMPS AND PACKING. Conventional centrifugal pumps with graphite impregnated asbestos or braided Teflon packing is used in most instances. Chempumps[6] (sealless, centrifugal pumps) can also be recommended.

SEALANTS AND LUBRICANTS. Xpando[7] and Q-seal[8] have given satisfactory service as pipe dopes in production facilities. Because of Dimazine's excellent solvent properties, no completely satisfactory lubricant has been found. The current best recommendation is a mixture of Apiezon L[9] and graphite.

DRUMS. No unusual practices are indicated for the unloading and handling of sound sealed drums of Dimazine. If a leak results from damage of a drum in transit, the spilled material should be washed away with water before salvaging the remaining Dimazine.

It is recommended that drums of Dimazine be left sealed, just as received, pending need for transfer of their contents. Before unloading, the drums are conveniently emptied by either pump or gravity flow.

If the drum is to be emptied in a single operation, it can be vented during withdrawal by loosening or removing the plug from the opening not used for the liquid discharge. It is normally unnecessary either to maintain a nitrogen atmosphere or to dry the air that is drawn into the drum as the liquid contents flow out. It should be pointed out, however, that an explosive mixture may be present in the vapor space of the drum if air is allowed to displace the contents.

Neither oxidation nor moisture pick-up should be significant under these conditions. Before discarding, the empty drum should be flushed thoroughly with water to remove any small amount of Dimazine remaining. For drums being only partially emptied, the most conservative method requires that an atmosphere of inert gas be maintained within the vapor space as the contents are withdrawn.

Storage

There appear to be no critical limitations on storage environment. Mild steel tankage is satisfactory. Tests have shown Dimazine to be thermally stable at temperatures well above those normally encountered in the atmosphere. It freezes at a very low temperature.

From a practical viewpoint, storage should be maintained comportably below the boiling point of the material (146°F). A limit of 120°F as the peak temperature for sustained period is recommended. Large quantities should be stored in comparatively isolated areas, and oxidants such as nitric acid, hydrogen peroxide and halogens should be kept out of the immediate storage area.



Large quantities of Dimazine must be stored in isolated areas, and away from oxidants.

Studies suggest the use of horizontal cylindrical tanks, maintained under a slight pressure. Mild pressurization under an inert gas, rather than atmospheric breathing, is favored for reduction of Dimazine losses from periodic fills and withdrawals and from daily changes in ambient temperature.

Fire Hazards

As noted earlier, Dimazine is flammable. Open fires, sources of sparking etc., should be avoided and all equipment in which it is handled should be electrically grounded. Explosion-proof wiring, lighting and motors are indicated for areas in which it is to be handled.

A flammable mixture is present in the vapor space whenever Dimazine is handled under air. This is not unique to Dimazine, but is characteristic of a number of other chemicals and fuels frequently handled under air. Some of these materials that form flammable vapors with air at ambient temperatures are ethanol, methanol, acetone, ether and JP-4 jet fuel. As a safety consideration, the use of a nitrogen atmosphere is recommended over Dimazine.

Dimazine fires should be combatted with large volumes of water. This achieves both dilution and cooling effects. Liquid Dimazine burns smoothly and cleanly, and is readily extinguished on dilution with two or more volumes of water per volume of Dimazine. Much higher concentrations in water will support combustion, although flame intensity is progressively weakened as the Dimazine concentration of the solution is lowered.

Carbon dioxide and water fog are also effective in extinguishing Dimazine fires. Chemical foams are not recommended since Dimazine tends to deactivate the foam-forming surfactant and to destabilize the foam.

Toxicity

The acute toxicity characteristics of Dimazine are similar to those of hydrazine, and moderate care must be exercised in its handling. Westvaco has been producing substantial amounts of this chemical for several years, and has had no case of acute poisoning or evidence of chronic poisoning.

Our medical surveillance program

	MIL-F-25604 Specification	Typical Dimazine
Assay	98 wt. % minimum	99.2
Specific Gravity @ 25/4°C	0.783-0.786	0.7845
Distillation Range		
10% Temperature	143°F minimum	145°F
90% Temperature	148°F maximum	147°F
Melting Point	−70°F maximum	−73°F
Color (light transmittance)	90% minimum	96%
Water Content, wt. %	0.3% maximum	0.1%

includes a pre-exposure physical examination. Personnel exhibiting anemia or evidence of liver disease are not used on the operation. Hemoglobin and white blood cell counts are made at intervals of six weeks.

The safety precautions recommended for our plant operators are as follows: (1) If the odor of Dimazine is apparent, use a respirator equipped with an ammonia canister. (2) Wear splash-proof goggles and vinyl-coated gloves. If possibility of gross splashes exists, suitable splash-proof garments are recommended. (3) If splashes do occur, wash thoroughly with water and launder clothing and other protective equipment before re-use.

The most complete studies on the acute toxicity of Dimazine have been made at or under contract to the Army Chemical Center where they are currently studying the effects of chronic exposure.

Propellant Applications

One of the outstanding propellant characteristics of Dimazine is its hypergolicity with fuming nitric acids and the very low ignition delay when used with this oxidizer. The ignition delay of this system is the shortest of any known —only a few milliseconds. It also has been satisfactorily used as a fuel with liquid oxygen. This system is not hypergolic but smooth burning results once ignition has been initiated.

The hypergolic character of Dimazine is utilized in a variety of ways. Propellant systems using only Dimazine and fuming nitric acid have been used very successfully. In other systems, a "lead slug" of Dimazine has been used to give reliable ignition to another nonhypergolic fuel system.

Dimazine has been used in blends with other fuels such as hydrocarbons to promote smooth burning. Rocket systems using Dimazine include the Army's *Nike Ajax*, the Air Force's *Rascal* and the Navy's *Vanguard*.

The results of a study of the hypergolicity of IDMH with IRFNA was reported by Potter and Byington at a meeting of the American Rocket Society in September, in 1956. They reported the following conclusions: (1) At atmospheric pressure, the ignition delay of UDMH in fuming nitric acid is very short, i.e., of the order of a few milliseconds. (2) Dilution of UDMH by up to 5 wt. per cent of water increases the ignition delay a small amount at −40°F. (3) Temperature, over a range of −65°F to 100°F, has little effect on the ignition delay of the UDMH-IRFNA system. Dilution with jet fuel (JP-4) increases the ignition delay only modestly at 70°F with a value of 30 milliseconds observed for a blend containing 40 wt. per cent UDMH. At −40°F the ignition delay of these blends rises rather sharply as the UDMH concentration is reduced.

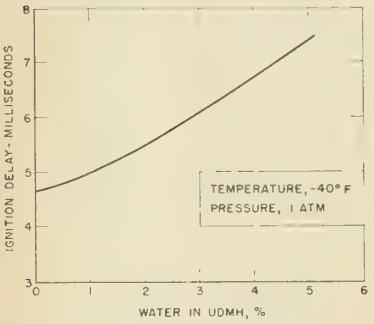
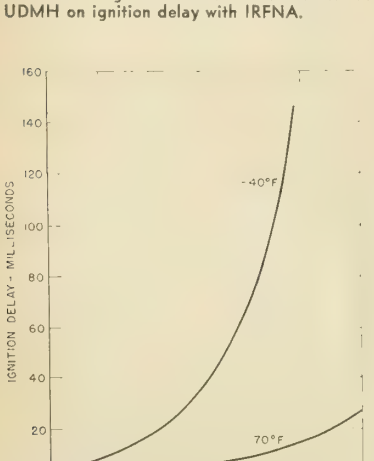


Table showing overall effect of water in UDMH on ignition delay with IRFNA.



Ignition delay of JP-4/UDMH mixtures with IRFNA showing delay in milliseconds.

Specifications and Analysis

A military specification, MIL-F-25604 (USAF), has been issued by WADC for unsym-dimethylhydrazine. We collaborated with WADC in development of this specification. Its key requirements are compared with typical Dimazine as shown in table.

Dimazine consistently complies with this specification and we see no economic penalty in maintaining this standard as opposed to turning out a material of lower quality.

We have proven the precision and accuracy of analytical methods for determining the properties listed in the above tabulation and will be pleased to supply copies of both the methods and the technical reports supporting them to those interested.

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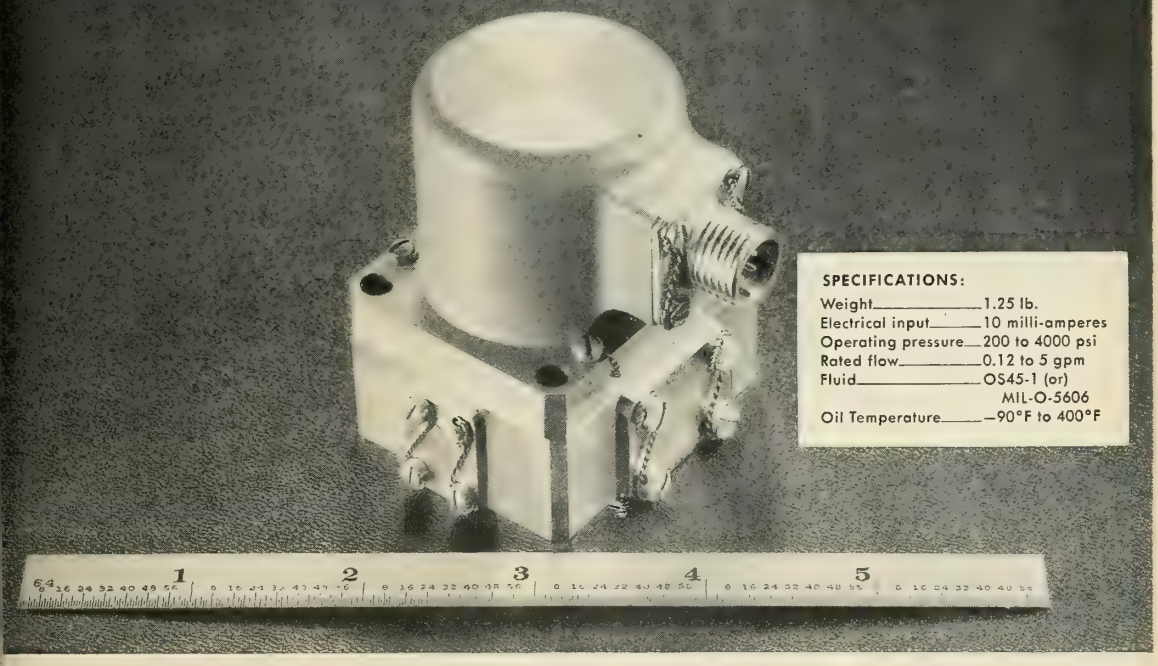
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the AiResearch time dwell electro-hydraulic servo valve



SPECIFICATIONS:

Weight	1.25 lb.
Electrical input	10 milli-amperes
Operating pressure	200 to 4000 psi
Rated flow	0.12 to 5 gpm
Fluid	OS45-1 (or) MIL-O-5606
Oil Temperature	−90°F to 400°F

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It is insensitive to varying spool friction loads.

It has a wide temperature range of efficient operation.

In combination with a matched actuator, the Time Dwell Servo Valve gives true $1/s^2$ dynamic performance. This allows the servo systems engineer to achieve system response, resolution and stability previously unattainable.

• *Outstanding opportunities for qualified engineers*

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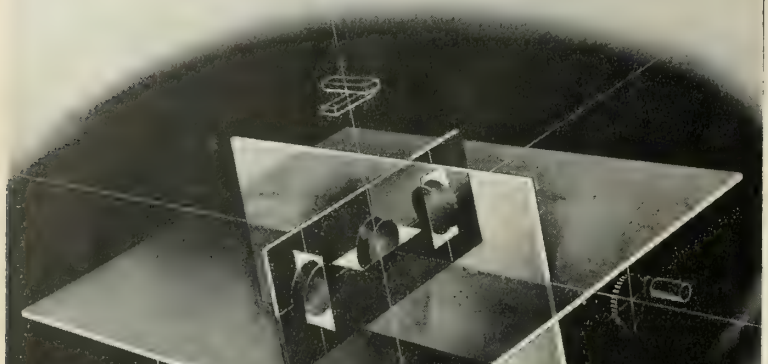
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	COMPRESSIVE YIELD STRENGTH—30,000 psi
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	HIGH NEUTRON—SCATTER CROSS SECTION
	HIGH MELTING POINT—2345°F
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UDMH are coal or natural gas, wate and air. Salt must also be included as source of chlorine if a modified Ras chig synthesis is used. Dimethylamine one of the building blocks for UDMH is made from methanol and ammoni and the second nitrogen in UDMH is also fundamentally derived from ammonia.

The equivalent of two moles o each of these chemicals appears i each mole of UDMH. When proceed ing through the nitroso route, hydroge is required to convert the nitroso t Dimazine. In the modified Raschi process, the ammonia is oxidized b chlorine. Chlorine and hydrogen ar cheap, readily available chemicals whic present no serious limitations to pro duction.

Less than one per cent of am monia-methanol capacity would be re quired to make 50-million pounds o UDMH annually. The processes in volved in the manufacture of UDMH are of a type that are readily adaptable to large volume production.

It has been Westvaco's policy t maintain capacity substantially in ex cess of demand. Engineering studie have been completed which will per mit prompt expansion of our facilitie if and when increased demand appears

The price of UDMH has bee steadily decreasing during the relative ly short time it has been in commerci production. Prior to 1954, the price o UDMH was about $15.00 to $30.0 per pound. In 1954 and 1956, this wa reduced to less than $4.00 and le than $3.00 per pound, respectivel Current price for tankcar quantities under $2.00 per pound.

Our engineering studies indica that a selling price of about $.50 p pound should be possible if large-scal sustained production is achieved. Th includes amortization of the investme and a modest profit.★

Footnotes

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2) Registered trademark of du Pont C Wilmington, Del.

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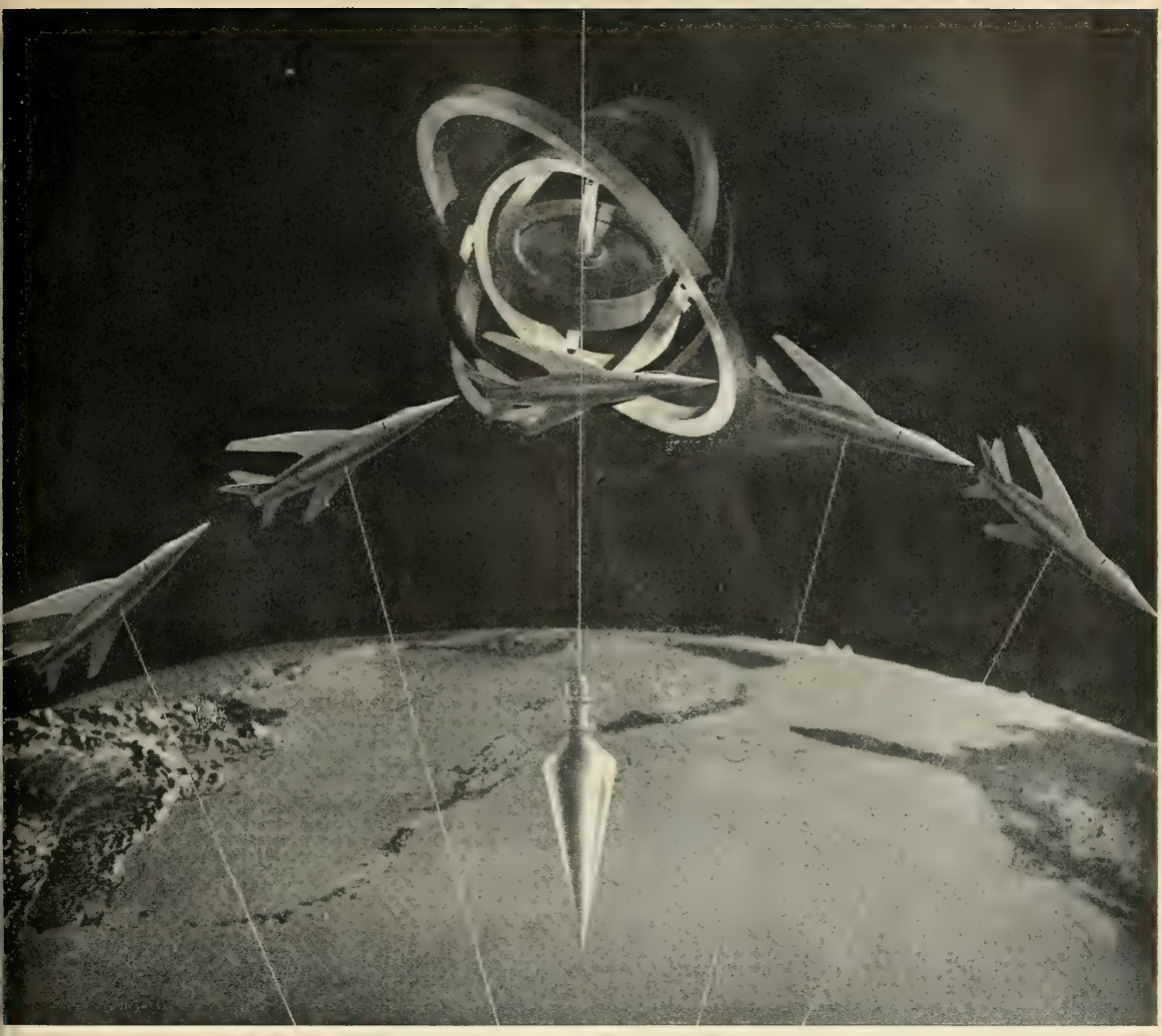
5) Registered trademark of Phill Petroleum Co., Bartlesville, Okla Supplier; Quaker Rubber Co Philadelphia, Pa.—Fabricator.

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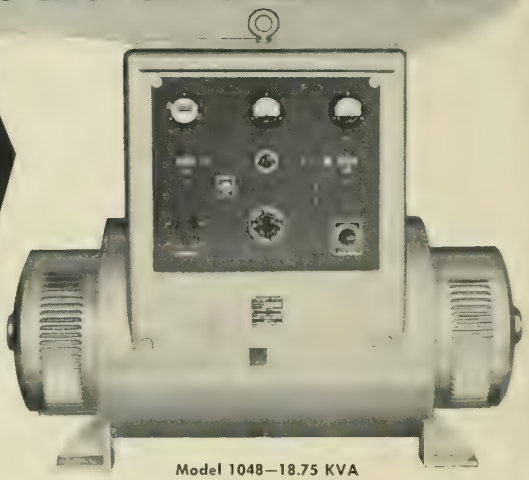
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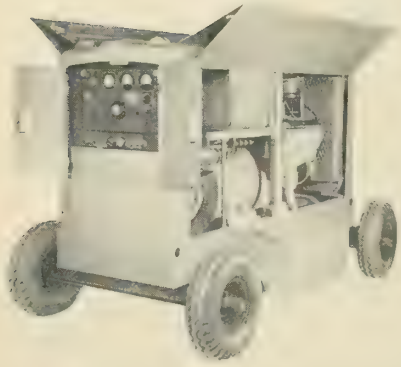
With the advent of jet aircraft, the merits of an a.c. electrical system is unquestionably the right choice, so the need for 400 cycle power is urgent. Research by Hobart indicates that units ranging from 3.75 KVA to 125 KVA are required. Design, development, and production of these new units are in progress at M.G.C. The Hobart d.c. line will, of course, take care of the limited supply of low voltage d.c. requirements on certain jet aircraft.

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Propulsion Systems Evaluation

By George P. Sutton

Chief, Preliminary Design Section
Rocketdyne

AN EVALUATION of future propulsion systems for space travel is, at best, highly speculative at this time. The technology of some of the more advanced propulsion systems needs considerable research and development. Some of them may prove to be fundamentally restrictive.

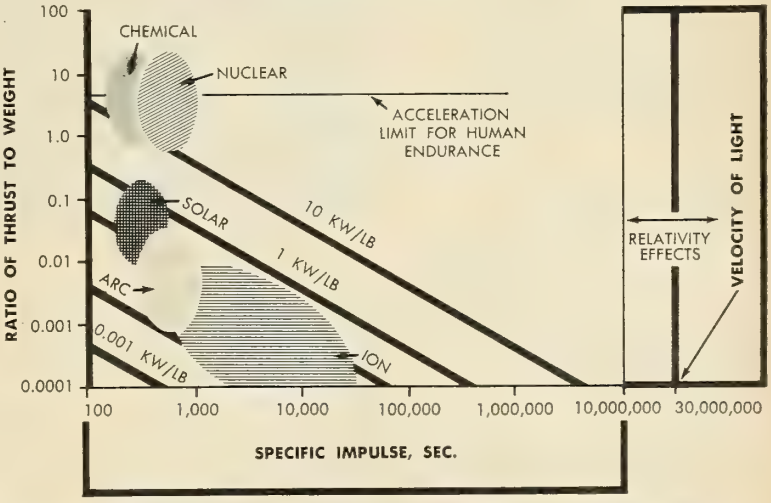
Analytical studies indicate that a number of propulsion devices, which will permit space travel, are theoretically possible. Those giving high performances will require a larger amount of energy expenditure per unit thrust. This implies that the problems of some of the more advanced propulsion systems will be more intimately associated with the energy source, rather than the thrust-producing device.

Many of the propulsion problems become more difficult when the mission requires a pilot or a passenger. Safety provisions, acceleration limits, hazard of radiation, or check-out procedures become more involved. From the propulsion standpoint, therefore, unmanned space flight will be easier to achieve at an early date.

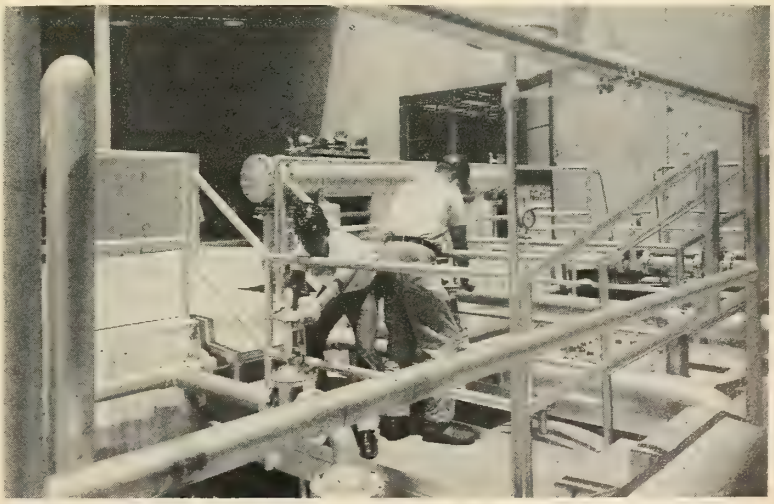
The evaluation of the relative merits of one propulsion system over another and the selection of optimum propulsion system parameters will require the examination of many factors, some of them still unknown. Therefore, it is not possible at this time to make a general statement as to the optimum powerplant for space flight. Very likely the vehicle will be a multiple-stage space ship and carry more than one type of powerplant, each to be utilized for a specific portion of the flight. A relative evaluation of the optimum powerplant, therefore, will require an evaluation of specific missions.

For takeoff from the earth and other large heavenly bodies, and in many cases for landing also, a relatively high acceleration is required. For these functions, a liquid propellant rocket may well be adequate. A notable contribution to space flight can be made by improving and refining existing chemical rocket engines.

Presently known devices appear to make flights around and to the Moon, Mercury, Venus, and Mars theoretically feasible. Multiple-stage devices being



Ratio of thrust to weight versus specific impulse, sec., of different propulsion systems.



Mechanics Walter Pressir and J. W. Stewart set water-flow control valves on Rocketdyne's high flow bench used to test fuel control components in large liquid fuel rocket engines.

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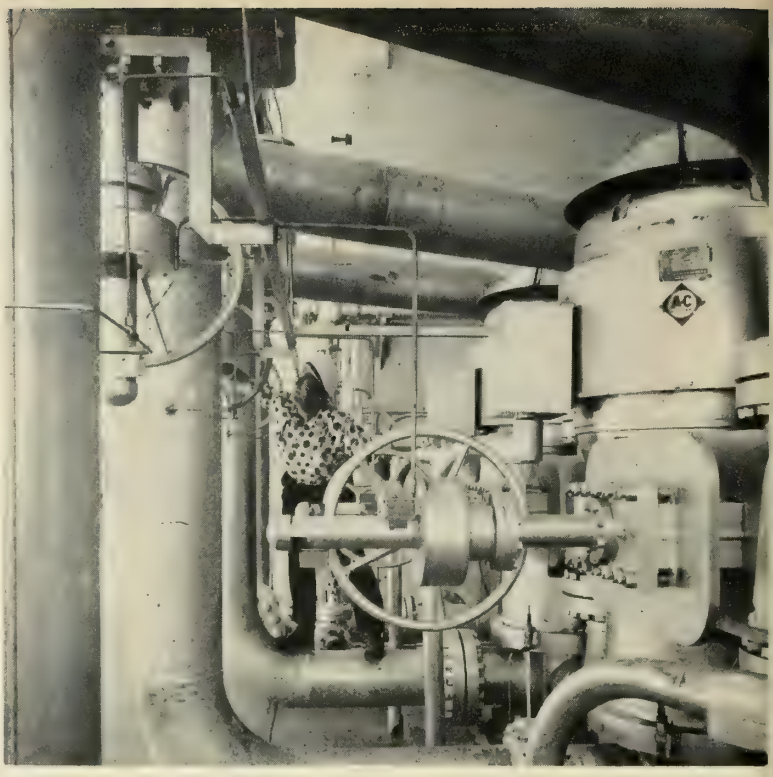
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Pipe lines from three multi-stage centrifugal pumps on Rocketdyne's test unit. Harold Hupp sets one of the valves on the equipment, the largest of its kind in the free world.

conceived can, with reasonable flight times, make it theoretically possible to fly missions to Jupiter and Saturn. There is no known powerplant today which would permit trips to Neptune or Pluto, or which would permit escape from the solar system in any reasonable length of time.

Several different propulsion systems will be considered here in very general terms.

Liquid Propellant

The liquid-propellant rocket today is well developed and relatively well understood. It uses a chemical fluid and a chemical liquid oxidizing agent to create thermal energy which, in turn, is converted into a kinetic energy in a nozzle. Apparently there are no fundamental limitations as to size of this propulsion device. Many different forms and types have been produced.

Rockets which produce only a few pounds of thrust, as well as those producing many tons of thrust, are entirely feasible. The operating duration is generally short (less than 5 minutes) and the accelerations are relatively high, yet adequate, for giving good maneuverability in space flight. Takeoff and landing accelerations of 0.12 to 2.0 g's and space flight accelerations of less than 0.25 g are considered practical.

The liquid-propellant rocket is excellent for take-off from a body of large mass, such as the earth, moon, or the planets. A vehicle designed for these takeoff and return missions and for limited space travel to nearby planets will very likely require multiple stages.

The high-energy liquid-propellant rockets are very similar except they give a somewhat higher performance. These rockets permit fewer stages or an improved vehicle mass ratio for a given mission, but they do present problems in logistics and engine design.

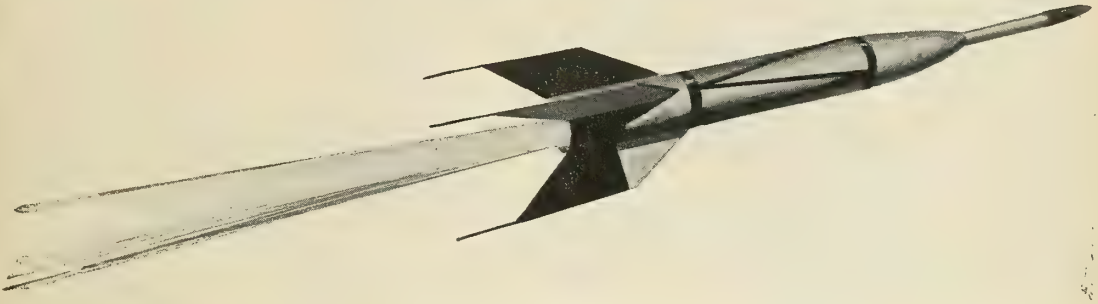
Nuclear Energy

A nuclear energy device achieves its reaction by ejecting a heated working fluid such as ammonia, helium or hydrogen. The energy released by the fission of uranium in a reactor is transferred to the working fluid which is vaporized by heating. The performance is limited by the maximum temperature that the nuclear reactor material can stand.

The radiation hazards inherent in this device from gamma rays, neutrons and alpha particles require special shielding provisions, particularly for applications where people are to be transported. Nuclear reactor heating offers a potential specific impulse improvement over the chemical propellant rocket by a factor of two or three. I

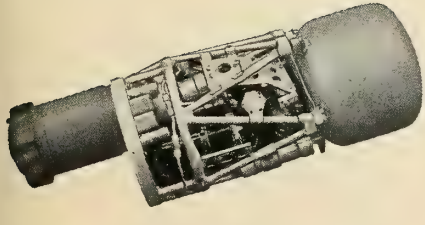


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general, the nuclear rocket appears to offer the same areas of application as the chemical rocket, except that the improved performance would permit a lower vehicle mass ratio and a smaller takeoff weight.

Free Radicals

If it becomes possible to store activated species of propellant, such as nitrogen or hydrogen, then it may be possible to attain a further improvement in performance by augmenting the energy release and reducing the molecular weight.

Solar Heating

The solar heating device collects radiation from the sun by means of a large optical system and converts this radiation to thermal energy. This energy is then permitted to heat a working fluid, such as hydrogen, to a temperature high enough to produce a reaction thrust.

This device has very low acceleration potential and a relatively low thrust output per unit of propulsion system hardware weight. They are not suitable for flight propulsion in the proximity of the earth or the planets. Acceleration will last over long periods of time and the thrust magnitude will probably always be relatively small. This fact limits the solar heating device to interplanetary space missions, and possibly to satellite sustaining missions.

Arc Heating

Electrical energy is discharged in an electrical arc which heats a working fluid, which is then expanded through a nozzle. The energy for the arc could emanate from various sources, such as captured solar radiation, a nuclear reactor, or batteries. Its thrust per unit engine weight is believed to be lower than that of the solar heating rocket.

Ion Rocket

Charged atoms (ions) are accelerated by electric fields to very high velocities. The electric energy is obtained from a nuclear reactor, batteries or a solar radiation system. The thrust-to-weight ratio is probably even smaller than that of the arc heating or solar heating device and the rocket is again limited to space missions.

Should the specific outputs of the powerplants mentioned be limited to perhaps twice their present value, then it follows there are no existing powerplants which would make possible travel to another star or even travel to the outer planets within the lifetime of a man in a space ship. The crew would die before the journey was even half completed. It will be necessary to devise new, more powerful, rockets to achieve flight to the stars.★



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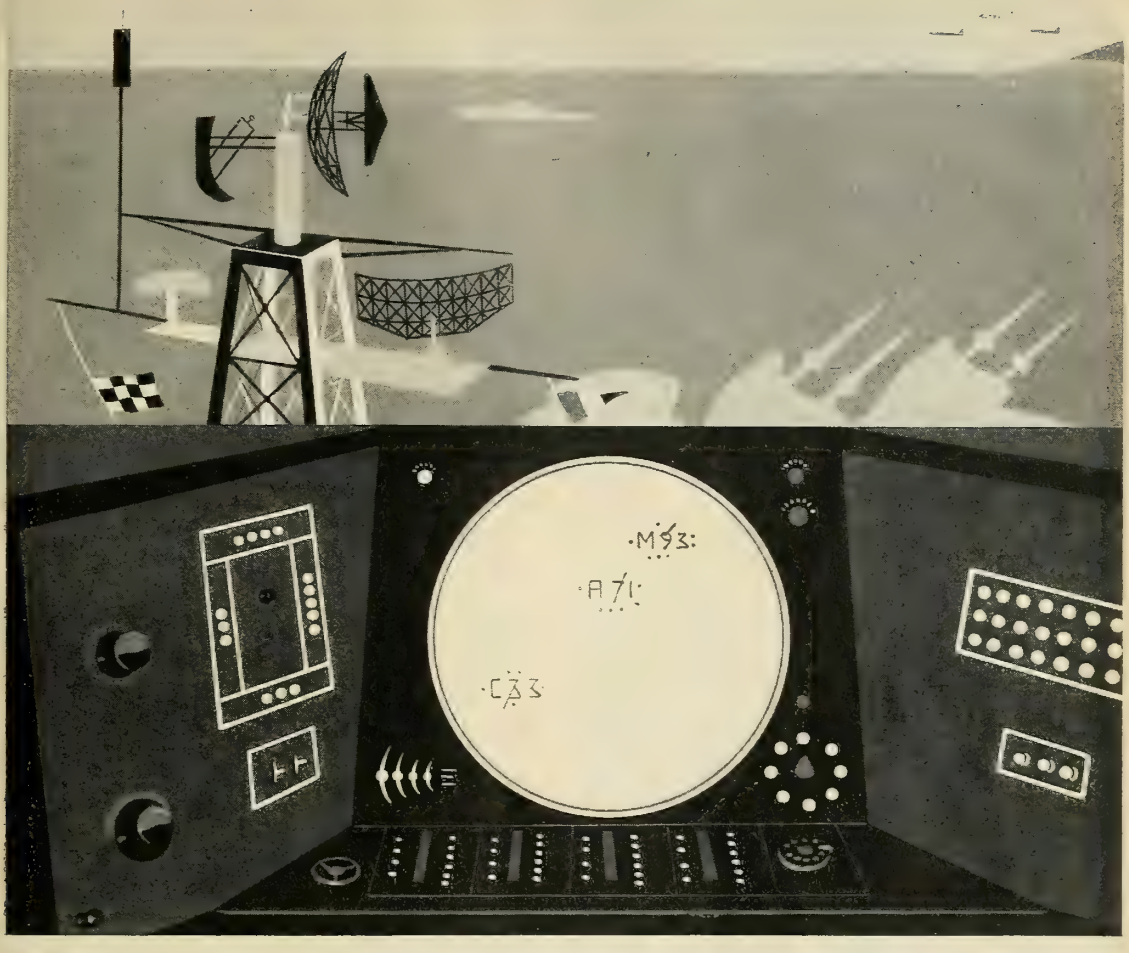
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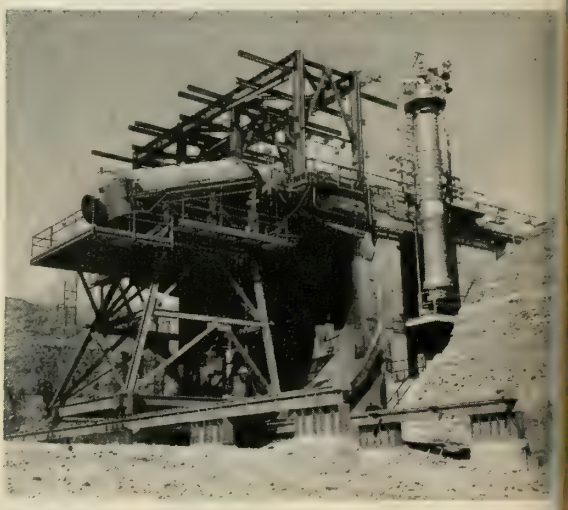
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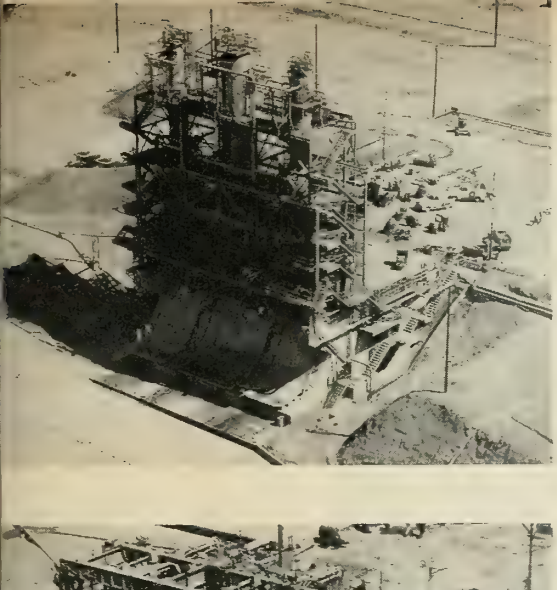
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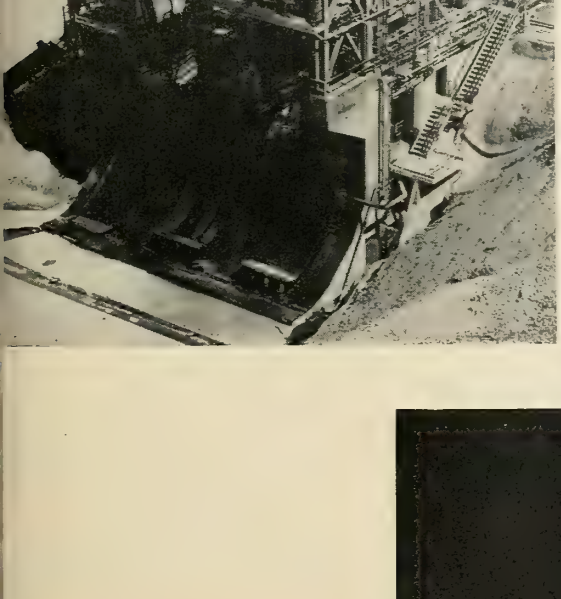


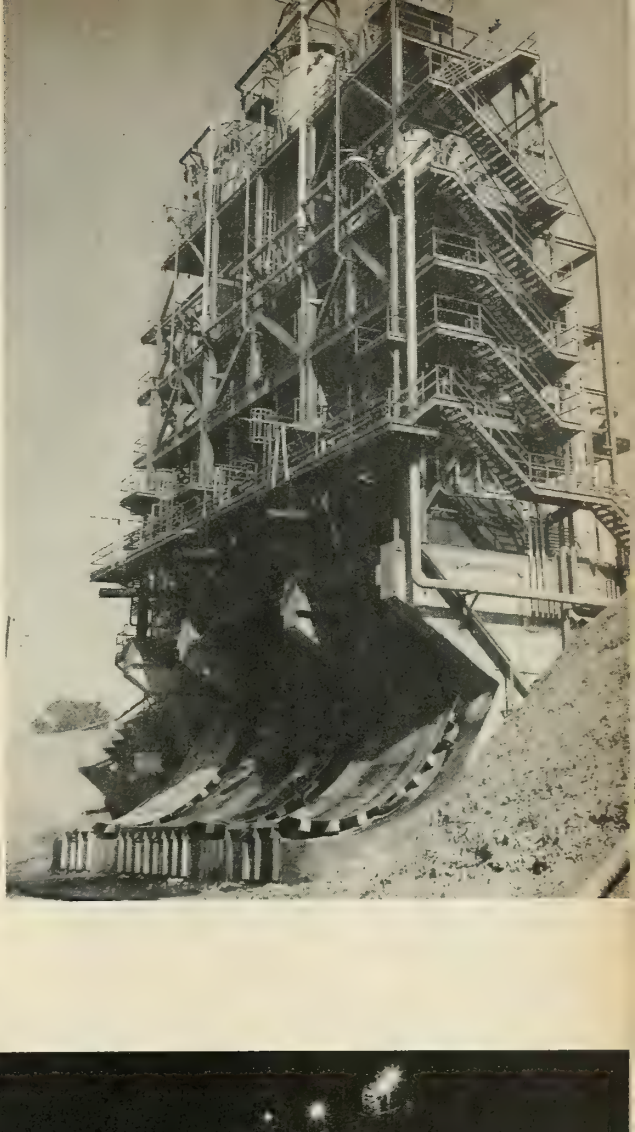




Big missiles mean big engines. And big engines mean big tes facilities. TITAN is a big missile—an ICBM designed to carry 300 pounds or more of thermonuclear warhead some 5000 miles. Aerojet General Corporation, TITAN prime propulsion contractor, has buil eight giant static test stands like those shown here at Sacramento Calif. Immediately above is the simulated high altitude test chambe Other views on this page show actual tests under way. Aero jet is not allowed to comment on whether any are TITAN engine









t doesn't take much examination of these ictures to see that rockets are an expensive usiness. The tons of concrete and close- olerance, high strength structure, water sup- lies for cooling the blast deflectors and all he measuring and calibration equipment nake these multi-million dollar monsters. The est stand to the right, shown both by day nd night, can take engines of over one mil- ion-pounds thrust. It cost $3 million to build. hough no one-million-pound thrust engines ave yet been fired, it may not be too long efore this is done. Unofficially, it's been tated that liquid engines of over 300,000- ounds thrust have already been tested. And elsewhere in this magazine, it is stated hat engines of virtually any thrust that may e required can be constructed. From a tate-of-the-art viewpoint, there's no limit.



TO NOURISH AN IDEA

Dr. Peter J. W. Debye, professor emeritus of chemistry at Cornell University, and Dr. Lloyd P. Smith, President, Avco Research and Advanced Development Division, discuss the Avco research program prior to Dr. Debye's recent colloquium at the Division's Lawrence, Massachusetts, headquarters.

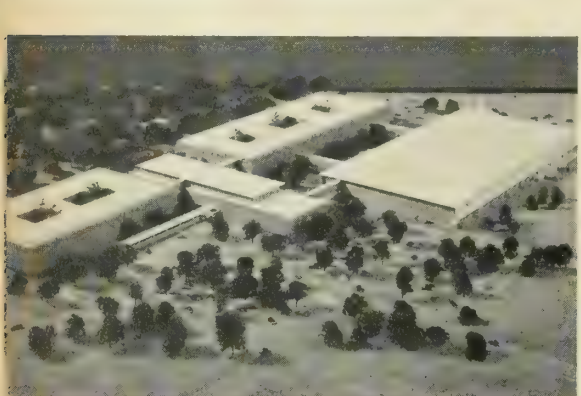
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Some of America's foremost scientists and engineers are at here. Consultants, like Dr. Peter J. W. Debye, contribute thr colloquia and the stimulation of the inter-disciplinary cur imperative to high-level scientific performance.

Avco's scientific approach to urgent national defense prob has already brought advances in high-altitude, high-speed f missile re-entry, aerodynamics, heat transfer, materials and areas. Practical problems have been solved; scientific hor have been widened. But the greatest challenge at Avco lies work yet to be done.



Pictured above is our new Research Center now under construction in Wilmington, Massachusetts. Scheduled for completion in early 1958, this ultramodern laboratory will house the scientific and technical staff of the Avco Research and Advanced Development Division.

Avco's new research division now offers unusual and exciting career opportunities for exceptionally qualified and forward-looking scientists and engineers in such fields as:

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Write to Dr. R. W. Johnston, Scientific and Technical Relations, Avco Research and Advanced Development Division, 20 South Union Street, Lawrence, Massachusetts.

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LOX . . . Mainstay Oxidizer for the Missile Age

By William H. Thomas, *Assistant General Manager*
Process Equipment Division, Air Products, Inc.

TOMORROW'S DEFENSE depends on a wide variety of highbrow systems. With scientific and industrial tools accompanying advanced military units in so many ways, cryogenic liquids such as oxygen and nitrogen have become as familiar in today's armed forces as ham and eggs.

LOX occupies a position of leadership mainly because it does one job supremely well. As missiles continue to influence our major defense efforts, only those systems with the highest performance capabilities may be considered for certain key jobs.

For packing energy into small volume with minimum mass, nothing yet developed can successfully challenge liquid propellant rocket systems. High specific impulse and ease of storing liquids in irregularly shaped spaces provide a very potent missile combination.

Why should one oxidizer stand out among the wide number of available liquids? The answer is practicability. In addition to high performance, LOX answers more of the cost, storage, handling, safety and logistics requirements than perhaps any other material contemplated for volume application.

More for Less

Available for pennies per pound, LOX costs less than coal in many areas. Few oxidizers are equally available for purification and refrigeration (atmospheric air is available everywhere), hence more reasonable in their cost than LOX.

Insulated storage facilities are available for LOX which limit losses to ½ to 1 per cent per daily use both for hauling and stationary storage. Storage aloft is not a serious problem as the rate of consumption in most missile equipment is so rapid that vaporization losses are inconsequential.

Handling LOX is similar to handling other fluids of high vapor pressure. As in any other such liquid system, for example, gasoline, absolute sealing can invite dangerous pressure buildup. Simple venting is the rule. LOX may be pumped, valved, filtered, vented and even spilled like most other warm or cold liquids. LOX has been handled commercially and profitably for a long time. Techniques developed over long years in the commercial oxygen industry are successfully practiced today throughout the military.

Safety is a critical factor in selection of materials and methods for defense. Systems so hazardous to personnel as to include high risks of nonperformance could be catastrophic in a time of real emergency.

LOX has a proven record of safe storage and handling. Warm vapors emanating from LOX are breathable and noncorrosive. Oxygen is used as a therapeutic agent in hospitals and is assuredly not poisonous. Combustion products of LOX with most fuels are also generally nontoxic and safe for breathing, so that personnel need not be restricted from access to a launching site because of atmospheric contamination.

No fuel-oxidizer combination is of any value unless available when and where it's needed. Success of any military operation depends on the effectiveness of supply lines and freedom from dependence upon questionable supply sources.

Today, LOX is available wherever standard highway trailers can be put down on a firm footing. Portable LOX plants, currently in production, are available for generating LOX from diesel fuel and atmospheric air anywhere on the face of the globe.

The efficiency of LOX production facilities today is such that one pound of diesel fuel may produce two pounds of LOX. Once a portable LOX facility is installed at an advance base, further problems of supply amount to the effective delivery of standard diesel fuel.

In summary, LOX is available at very low cost, may be handled and stored effectively by routinely trained personnel, and may be produced anywhere in the world where a supply of fuel is available for an internal combustion engine.

On-Site LOX Generation

For many years, most oxygen was manufactured in central generating plants, compressed as a gas and distributed in heavy cylinders. Later, liquid LOX became commercialized because it afforded more efficient distribution. However, despite handling economy, delivery costs still soared as a result of extensive manpower needs and high labor costs.

Improvements in manufacture and the development of advanced types of on-site oxygen generating equipment brought a significant change in the shipping and storing of oxygen. Today, most large industrial consumers prefer to establish oxygen generators within the boundary limits of their own plants, saving transportation costs and utilizing free local air.

LOX requirements, dating back to Goddard's experiments on rocket engines and missiles in the early '20s, were supplied in relatively small quantities from commercial sources. As the U.S. military missile program gained momentum, it soon became apparent that vast quantities of LOX would be required at areas remote from existing large oxygen producing locations. Thus, the on-site generator, born of industry's needs for cost reduction, came to serve military requirements.

Military 75 Ton/Day LOX Generators

These units are designed for meeting the following basic requirements:

1) Low cost and high operating efficiency.

2) Minimum of utilities.

3) Reliability for continuous operation.

4) Transportability.

Large LOX producing facilities which meet the above requirements are currently "on-stream." Each facility is made up of individual LOX generating units which are considered to be a maximum size compatible with railroad and highway transportability or packaged components. Each LOX generating unit produces 75 tons per day of liquid oxygen simultaneously with 7.5 tons per day of liquid nitrogen, each at 99.5 per cent purity.

Multiple LOX generating unit facilities are currently in operation and under construction at stations in California, Florida and Colorado.

The 75 ton/day LOX generator employs a high pressure cycle, with certain process and equipment innovations designed to combine lowest initial investment with highest operating efficiency.

Filtered air is compressed in a multi-stage compressor to 2000-3000 psig. Between the second and third stages of compression, the air is passed through a caustic scrubbing system to remove carbon dioxide from the air stream.

Air leaving the fifth stage of the compressor passes through a desiccant-type drier system to remove moisture from the air. After the air drier, the air stream is split. One stream passes through the main heat exchangers, being cooled by effluent gases from the distillation column and is expanded through a valve in the high pressure column.

The other portion of the air stream is expanded from compressor discharge pressure to an intermediate pressure through a reciprocating expander, warmed through coils in the main heat exchanger and expanded into the high pressure column through a centrifugal expander.

A double rectification column is used. Crude liquid oxygen from the high pressure column is passed through hydrocarbon absorbers before being expanded to the low pressure column. Liquid nitrogen product is withdrawn from the stream which also provides liquid nitrogen reflux to the low pressure column.

Liquid oxygen is withdrawn from the bottom of the low pressure column. Effluent nitrogen-rich gas from the low pressure column is warmed in the main heat exchangers against incoming air and discharged to atmosphere.

A portion of the warm, effluent gas is used to load the centrifugal expander and is then used for reactivating the air driers, hydrocarbon absorbers and reciprocating expander oil filters.

Actual operation of 75 T/D LOX generators have resulted in an over-all cycle efficiency (power cost) of approximately 780 Kwh/ton of LOX plus liquid nitrogen. Actual operating costs for large quantity production rates have been reduced to approximately 0.7 cents per pound of delivered LOX and liquid nitrogen.

The 75 T/D LOX generator is designed to operate with electrical power as its only essential utility.

It is required that these LOX generators operate in remote areas, often where no cooling water is available. Therefore, the air compressor is equipped with large air-to-air inter- and after-coolers. It is important that the generator have a high reliability factor.

Several units have been in operation for over a year with very high "on-stream" factors. Actual production has been about 10 per cent over the rated capacity.

Because the use of the LOX may be cyclic with high peak requirements and also periods of full storage, it is very important that the generators can be taken "off-stream" and put back "on-stream" with a minimum delay in production.

Experience has shown that approximately five hours are required for a single warm generating unit to be placed in full production. Approximately one-half is required to re-establish production from a "cold" start.

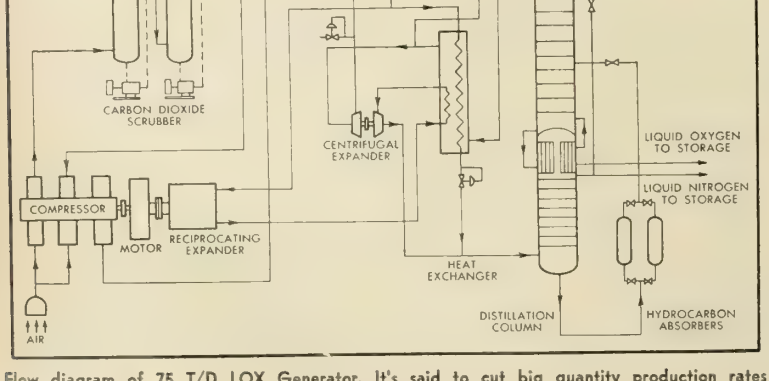
Occasionally, any high pressure cycle LOX generating unit requires defrost of the main heat exchangers. This unit is designed so that the heat exchangers can be defrosted independently of the main cold equipment. The total time required to defrost the main heat exchangers, and cool down again to normal LOX production, is five hours.

The size of the LOX generators developed for the Air Force missile program was dictated by the transportability factor. Even though the generator is large, the components including "factory packaged" cold boxes are all capable of transport by rail or low-bed trailer which permits a minimum of erection time and reduces erection costs. It is estimated that the cost of a factory packaged cold box of this size is about 75 per cent of the cost of a field assembled cold box.

The importance of LOX in this country's missile program is firmly established. It is already being produced in large volume for the missile program by the most modern and efficient type of equipment available and at a cost which assures its expanded use.

Vast improvements have been made in rockets and missiles since Germany, in military desperation, launched its first V-2 rocket against England. The efficiency of a missile depends on many things. Not the least of these is the fuel oxidizer. It must fulfill many exacting requirements.

Technological advances in low temperature processing have brought LOX production to a high point of safety and efficiency. It can be produced anywhere and transported safely in large volume. We at Air Products are proud to be a part of our country's missile program—and look forward to new developments in the field of applied cryogenics as it affects this vital defense effort.★



Flow diagram of 75 T/D LOX Generator. It's said to cut big quantity production rates to about .7¢ per pound of LOX and liquid nitrogen. Designed to run by electric power.

ENGINEER STILL AT WORK



is 2:42 A.M. and somewhere a man lies awake, mentally developing endless equations—studying prints and ıematics his tired but sleepless mind projects upon his bedroom ceiling. rhaps he is the man who will be responsible for a missile of unbelievable range d accuracy—for a faster, better aircraft to make possible the peaceful sleep of ıntless millions.

ere isn't much glory in the work he is doing. He wears no wings pinned to his rt as he bends over his drafting board. He never makes the headlines nor is his picture ead in the news magazines. Day after day, people pause momentarily—look up—but seldom lize the vapor trail they see in the sky once existed only in the mind of a man—an engineer with vision.

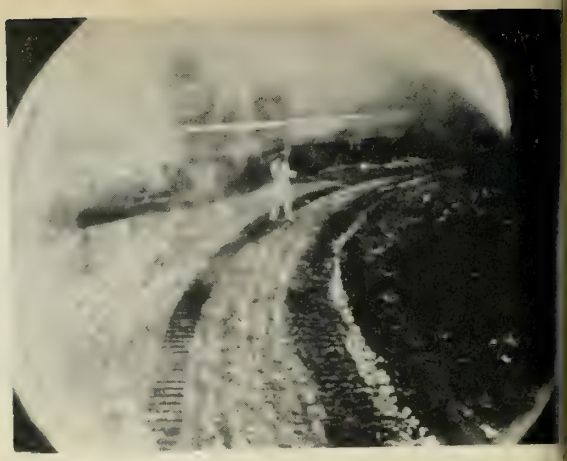
ı salutes the engineers of the nation, dedicated to the task of building a stronger, happier America. We at Sun join h the aeronautical and astronautical industries in urging young men and women to prepare themselves for this at profession—now on the threshold of challenging the universe! Sun is proud, too, of the role it is playing in the ft progress toward aeronautical and outer space supremacy—helping to make the engineer's job easier by furnishing ı with vital testing tools and equipment. If You have a testing problem—if You need the right equipment to make r job easier—we suggest you put our engineers to work.

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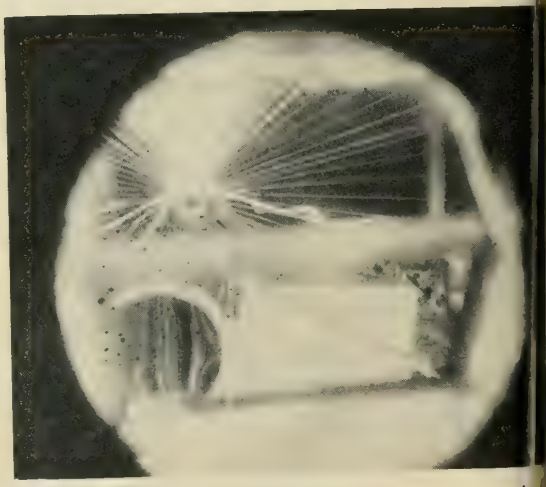




LEFT—The huge Winzen polyethelene balloon, with Major Simons suspended in capsule, rises out of open pit iron mine in Minn.
ABOVE—Porthole view at instant of launch. Crewmen are Winzen Research technicians. Man in center is holding capsule antenna.

PRELUDE to SPACE



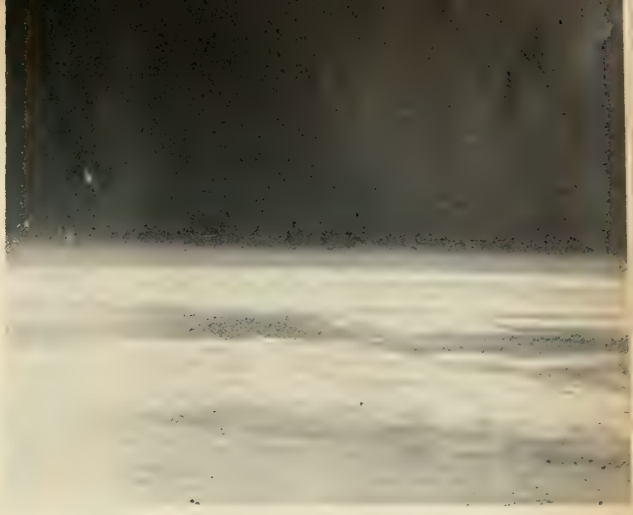


Mirrow mounted outside porthole afforded Major Simons a vi
balloon and chute shroud lines (upper) and ballast can (lo

An infrared view of the earth between Wadena and Fergus, M
taken on the first day. Temperature device is seen at lower r
Temperature within the capsule was held near constant by
flective insulation, an air circulator and an electric he



akes of uppper Minnesota seem small in this photo, shot near
ne peak of balloon's ascent. Earth's curvature is discernible.



Storm center, reported to ground stations by Major Simons, from approximately 100,000 ft. in the "unfriendly realm of silence."

xhausted and disheveled, Major Simons
eceives a blood test from an Air Force
urse shortly after landing. The capsule lies
n its side where it toppled during land-
ng. Shortly after boarding the pickup heli-
opter, he succumbed to a much needed
leep. Although he had planned to take
hort naps during his balloon flight, the
nany duties required kept him awake.







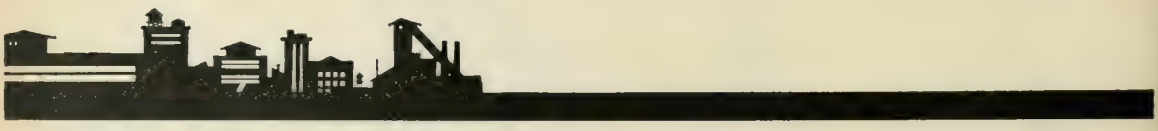
f-photograph of Major Simons taken near
peak of his 102,000-ft. ascent. He was
fined to the capsule for 42½ hours.



er a short sleep, Major Simons eats ham-
ger while calling his wife in Alamogordo,
M. Scott William, 3, sitting by Mrs.
ons, holds father's cap. Standing, left
right, are Samuel J., 9, Susan Ann, 10, and
y Jo, 8. Major Simons' remark upon en-
ng the phone booth: "Another capsule!"







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Non-Metallics for Missiles

Non-Metallics Take over Where Metals Leave Off

By John H. Lux* and Robert L. Noland*

THE RAPID GROWTH of the rocket and missile field has placed a great emphasis on production. Severe environmental conditions have resulted in a heavy emphasis on non-metallic parts as construction material. These can stand higher temperatures, are lighter in weight, better insulators, easier to fabricate, and have a wider variety of properties than metals. Among the missile non-metals are a family of proprietary materials made by Haveg Industries, Inc., and its wholly owned subsidiary Reinhold Engineering and Plastic Co. These are now used for components in 17 different types of missiles.

Proprietary materials such as Rocketon and Missileon are fabricated in pieces from ¼-inch in dimension, weighing only a fraction of an ounce, up to single pieces weighing as much as 50,000 pounds each. They may be finished by standard metal machining procedures and, in general, tolerances are fairly close to those encountered in the metals machining field.

Properties of these materials at temperatures about 14,000°F are still undisclosed, but in tests conducted, performance was considerably better than for magnesium oxide. During a 20-second run at temperatures ranging from 9,000°F up to 12,000°F, a half-inch thick disc of this material showed very little erosion and no cracking. This suggests the material could play a major role in the solution of severe reentry problems.

Haveg compounds are not metals, plastics nor ceramics, but a combination developed for high temperature operation. At high temperatures, the organic binder is pyrolyzed or reacts slowly with the high melting inorganic silicates, giving a surface which has the ability to resist erosion and the conductance of heat while most of the energy is reflected from the surface and subsurface back into the flowing stream of gases.

Among the items made on production schedules at the present time are blast tubes for use at temperatures approaching 6000°F., insulators, insulator adapters, motor cases, rupture discs, throats, jet vanes, jetevators, combustion chambers and nose cones.

Production techniques already enable nose cones up to 108 inches in diameter to be fabricated on regular plant equipment. Several of these can be made daily and at very low cost.

Production Techniques

There are at least ten different methods of handling the materials; extrusion, internal spinning, external spinning, indenting, casting, pressure molding, transfilling, hand lay-up, bag molding and filament winding. In addition, there are the same finishing operations used for metals, such as cutting, turning, threading, drilling, tapping, planing, milling, grinding, and coating.

While extruding is familiar to everyone in the metals and thermoplastic industry, it also works with thermosetting materials such as Rocketon and Missileon. The compound is forced through a cold or heated die or mandrel to form the shape desired, and the material cures on, or shortly after, emerging from the die. This is used, for example, in making blast tube insulation.

Units up to 12 inches in diameter and up to 20 feet in length may be produced in this manner either batchwise or continuously. In instances where post curing or post forming is desirable, this type of operation may be followed by pressure molding, indenting or other processes.

For large insulation systems or blast tubes up to 12 feet in diameter, extrusions are not feasible. Internal spinning is necessary. Here high temperature compounds are "spun" to an outside mold surface and compacted by centrifugal force or by pressure.

Pieces may be used in the steel structure in which they are spun, or may be removed by means of mold release and utilized unsupported. An example of process was in the coating with Missileon of the interior of a steel missile tube six feet long and six

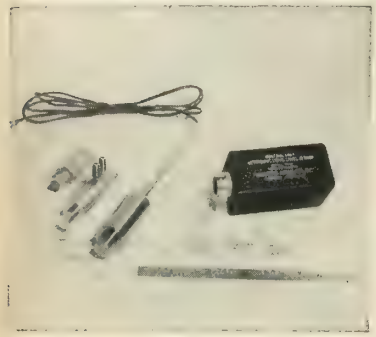
* *President, Haveg Industries, Inc.* * *Exec.-Vice President, Reinhold Engineering and Plastic Co.*

Left, Rocketon liner for solid propellant motor nozzle. Right, equipment now in place as it may be used for mass producing high temperature reenty nose cones for ICBMS.





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MATERIAL TYPES

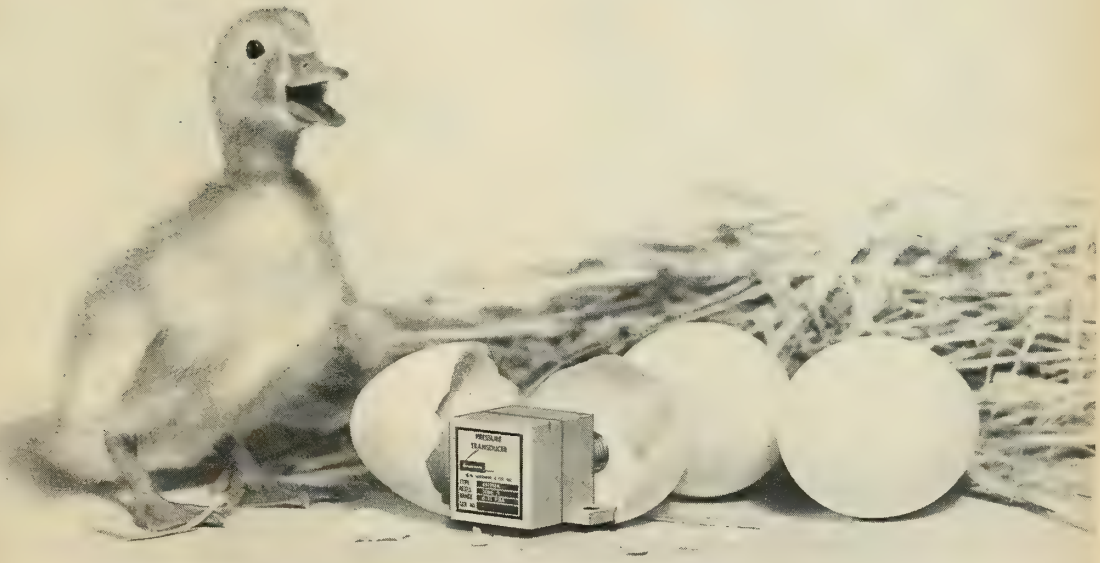
TYPE	USES	CONDITIONS
Rocketon	Missile Insulation Insulator Adapters Blast Tubes Nozzles Flame Deflectors	Up to 6000°F., several minutes, up to 3000°F., for one hour. Mach 0.1 to Mach 1
Missileon	Same as Rocketon Protective Insulation	Capable of standing *much* higher temperatures than Rocketon at low gas flow
Planeton	Jet Vanes Jetevators	Up to Mach 3 with temperatures in range of 5000°F., permanent operation at 550°F
Satellon	Same as above	Higher temperatures operations than Planeton but for lower gas velocities
Orbiton	Missileon reinforced with glass cloth	Same as Missileon
Mercuron	High temperature electrical insulation, Jet insulation	Designed for permanent operation at 700°F
Terran	Adhesive for assembly of insulating materials to steel	In conjunction with insulating materials has withstood the same conditions of the above insulations
Reinhold Epoxies	Structural parts in missile and aircraft applications	Environment temperatures under 300°F
Reinhold Polyesters	Same	Environment temperatures under 200°F
Reinhold Diallyl Plthalate	Electronic parts where low dielectric constant and low water absorption are required	Temperature under 200°F
Reinhold Phenolic Glass	Same as Rocketon	Up to Mach 3 with temperatures in range of 4000 to 5500°F, Continuous operation at 450°F
Reinhold Filament Wound	High strength of structural parts in missile and aircraft applications	

inches in diameter with a closed end. The spun interior was cured and machined right in place and then forwarded for loading with propellant. In both internal and external spinning, an outstanding resistance to erosion is developed by virtue of the fact that the filler structure is oriented circumferentially to the direction of gas flow through the tubes. Erosion resistance is improved up to ten times previous best values.

In contrast to internal spinning, there is no limit in size to external spun pieces. For example, the whole 8-foot length of a rocket unit was coated with Missileon ½ inch thick (including the nose cone), followed by a polishing operation which provided a brilliant marble-like highly reflective surface. Rolls, 12 feet in diameter, have also been coated. Venturi sections up to 20 feet in length have also been made, and shapes such as elbows are

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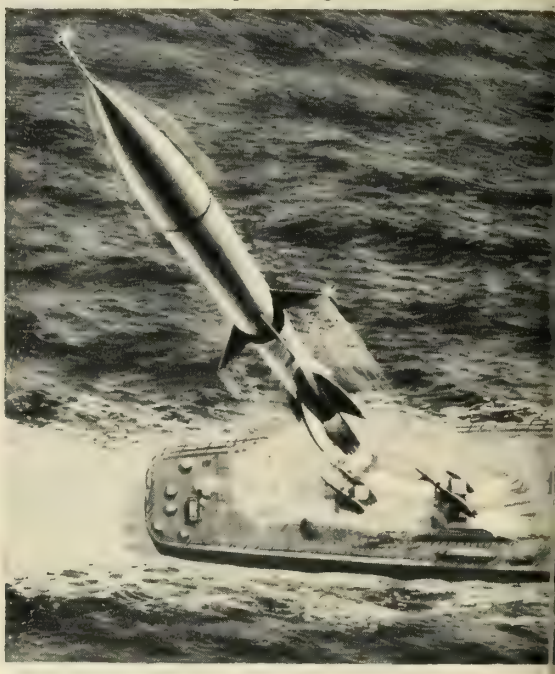


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easily converted by spinning first in one direction and then changing the axis and completing the job. External spinning also allows one to build up the strength by adding additional wall thicknesses or by inclusion of reinforcing materials such as glass cloth or other fibrous materials.

Indenting is a general process where a clay-like high temperature compound is forced, under low pressure, to conform to an irregular shape. Using these techniques, such peculiar devices as angular exhausts, angular tail cones, reversing chambers, auxiliary tubes and igniters may be installed in rocket motor systems.

Casting techniques are useful for filling a shape for either protection from heat to provide electrical insulation or to provide extra strength or rigidity.

A large amount of engineering and technical effort has been directed toward the development of high pressure molded parts containing large percentages of inert fillers, such as glass and asbestos. In the fabrication of these parts, hardened chromium-plate match-metal steel dies are employed.

These dies are usually designed to yield parts that conform to the drawing requirements without subsequent machining operations. By proper control of the die design it is possible to mold satisfactory parts having very close dimensional tolerances. For example, with high pressure molding, Planeton has replaced a molybdenum-tipped graphite jet vane. The molded vane is not only more economical to produce but also has superior performance characteristics in the jet stream.

Many other rocket and missile parts are being produced by high pressure molding operations, such as nozzle and throat sections, exit cones, heat insulators and various other motor internal components. Molding requires high temperatures and pressures varying from 100 to 15,000 psi. The actual molding pressure, temperature and cycle is a function of the parts design as well as the type of molding material utilized. This method is particularly valuable for mass production. The size can vary from a few grams to as high as 450 pounds.

Great strides have been made recently in the molding of close-toleranced parts for the electronics industry. For example, in one large electronic molding there are approximately 100 rare-metal plated inserts positioned relative to each other by close (less than .001 inch per inch) dimensional and angular tolerances. The tolerances are such that it is necessary to maintain tolerances of less than .001 inch per inch. This part was put in production at a cost far less than that of the hand-fabricated part.

In areas where a moderate number of parts are needed (normally 50-100), it is too costly to buy a complete match metal die mold and to set up on a production basis. These units may be made by buying an inexpensive steel mold which is then filled by transferring the proper amount of compound by means of a hydraulic ram. Once the mold has been filled under pressure, it may be moved to curing ovens for final completion.

When it is impossible to utilize the existing mechanical techniques because of the size and shape of a unit or for the fabrication of a single model unit, hand lay-up is often the simplest. Skilled operators, using melamine, epoxy, phenolic or polyester resin, impregnated upon glass or other fibrous materials, actually make the compound conform to the shape of a surface or mold, and put on as many thicknesses as desired to build up the desired surface. Shapes 250 feet long and 20 feet in diameter are common. In such a process it is easy to install honeycomb and other inserts.

Bag molding is a process of pressing a previously prepared lay-up between a fixed form and a flexible bag by application of vacuum to the area between the mold and the bag or by use of steam or other fluid pressure. Both wet and "prepreg" type lay-ups may be used. In contrast to match metal die moldings, where both sides are finished to good surfaces, only one side is in the finished state. Heat exchanger ducts, for example, can be manufactured this way.

Filament winding consists of feeding resin-impregnated continuous glass filaments to a rotating mandrel, with the external dimensions of the mandrel conforming to the requisite internal dimensions of the desired part. By use of the continuous glass filaments it is possible to realize structural strengths considerably higher than those obtained by other fabrication methods where glass filaments are utilized. It is possible to realize tensile strength as high as 150,000 psi under ideal conditions where the filaments are all aligned in the same direction.

By varying the alignment of the filament in the fabricated structure, it is possible to alter its structural characteristics. For example, the 150,000 psi strength condition is achieved in a cylindrical vessel where the fibers are oriented to resist only hoop loads. For a closed end pressure vessel, it is possible to align the fibers in the direction of the principal stress and thus obtain the ultimate structural use of the glass filaments. The resulting pressure vessel

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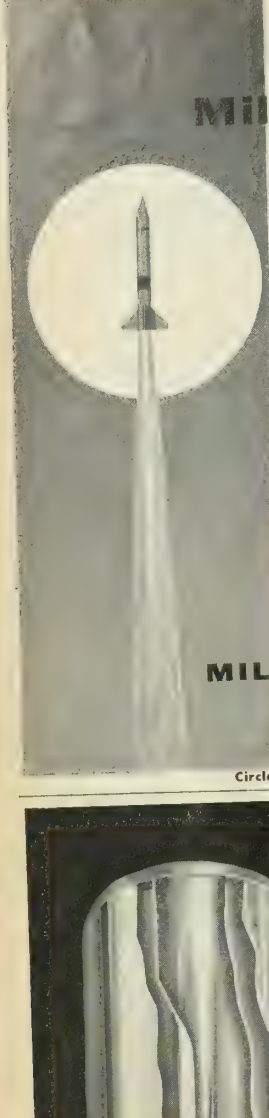
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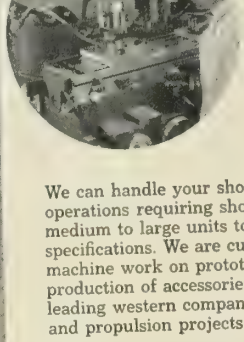
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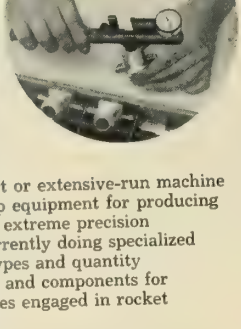
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can have a hoop-burst strength as high as 80,000 psi, the limiting design feature being the method by which the end closures are attached to the cylindrical section of the vessel.

Since the glass filament wound structures have a low density, approximately .067 pounds per cubic inch, and relatively high strength characteristics, they can be utilized to great advantage in missile and aircraft applications. For example, Reinhold designed, developed and put into pilot production, an all-plastic, small caliber ordnance rocket. Its performance characteristics were far superior to those obtained with a similarly designed all-metal round. The effectiveness of the all-plastic round is demonstrated by its reaching a burnout velocity of 3800 fps as compared to 2300 fps for the metal round.

This method of fabrication makes it possible to obtain excellent productivity. Of 8000 four-inch diameter couplings currently no units have failed the 100 per cent hydrostatic pressure test. This unit will satisfactorily withstand an external pressure in excess of 5000 psi.

Production methods and costs often depend on quantity. For example, a prototype might me made for $100 by an indenting process using a cheap wood mold. Following the success of such a unit, 50 might be made for $50 each, using a low cost metal mold. Finally, production of 5000 units would be carried out at $20 each using a match metal die mold in a large automatic press. Haveg's large stock of over 30,000 different molds enables them to make almost half their new items with an insignificant mold charge.

For machine finishing, cemented carbide tools of the harder grades and coarse abrasive wheels are preferred. Common tool steel may be used, but it dulls rapidly. Another technique is to finish each part independently, assemble in the plant and then perform a second finishing operation. Blast tubes can be cemented into the steel chambers by means of Terran flexible cement. The joint between the two insulation materials is then made by indenting with Rocketon cement which is of the same composition as the insulation and will withstand operation up to 6000°F., at sonic velocities.

These materials have many advantages over graphite as a material of construction. Probably their most important property is their high degree of reflectance at high temperatures. Since a major portion of the heat transfer at temperatures above 2500°F. is by radiation (note the high value of the T^4 factor in the Stefans-Boltzman equation), the degree of whiteness or blackness is extremely critical. While

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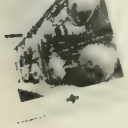
When tomorrow's rocket takes off for a destination in space, its propellant will undoubtedly be a high energy fuel-oxidant system . . . and the oxidant may well be ozone.

In the comparatively short period since the development by Welsbach of dependable tonnage ozonators, the applications of this versatile low-cost oxidant have broadened to include practically every industry. It is recognized for its specificity and purity in chemical synthesis reactions and has made possible increased yields of high quality products from cheap and abundant raw materials.

Specific uses for Welsbach ozone include the production of lubricants for high-speed motors and jets and the oxidation of corrosive chlorides in nitric acid recovery following atomic fuel extraction. Ozone also effectively removes phenol and cyanide from industrial wastes, and improves the oxidation characteristics of mineral oils.

These and numerous other uses indicate that the scope of applications for Welsbach ozone is unlimited. Through constant research, Welsbach continues to enlarge the field for ozone as an oxidant. With an unparalleled background in the design and construction of tonnage ozone plants, Welsbach offers you a long and varied experience in ozone application.

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the reflectivity of most materials ranges from 40 to 70 per cent, Rocketon and Missileon have reflectivities of 95 per cent or above at 3000° to 5000°F. This compares with a factor of 50 per cent to 52 per cent for graphite under the same conditions.

A further advantage is that Haveg's insulating value is many thousand times better than graphite so that in addition to not absorbing the heat, any heat which is absorbed is not passed on to cause deterioration to other parts.

Other advantages over graphite include: Brinell hardness of about 42 where graphite is so soft that it does not even appear on the scale; fabrication into an unlimited number of shapes and sizes; thermal shock resistance—pieces of Haveg have gone from room temperature to 5000°F., in a period of a few seconds, in many hundreds of tests without failure.

Molded pieces of Haveg may be joined to other pieces or have igniters or other units cemented in after formation. For example, where it was desired to place an igniter in an afthead insulator of Rocketon, all that was necessary was to drill a hole in the Haveg of the proper size, insert a small 2-inch Haveg tube and then apply Haveg Rocketon cement. In one hour the job was complete and ready for use. With most other construction materials, this is an impossible feat.

Another limitation of graphite is its use with chemicals. Haveg is completely resistant to most of the chemicals used in both liquid and solid propellants. Its silicate structure is chemically inert to everything except hydrogen fluoride. And, in instances where HF is encountered, there is a grade of Haveg which will also give satisfactory performance here.

Finally, it is well-known that graphite, in an oxidizing atmosphere reacts to form CO^2 or CO and this reaction begins at 500°F., in air—700°F., in steam and 900°F., in carbon dioxide. Rocketon and Missileon are unaffected by either oxidizing or reducing atmospheres up to 5000°F. Beyond that temperature, little is known.

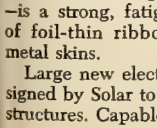
Rocketon for nuclear application has been tested at 10^9 roentgens for a period of several months. Examination of the test samples showed no appreciable change in chemical or physical properties. Oak Ridge National Laboratories predict that Haveg Rocketon will withstand higher levels of radiation. In equipment exposed to low level radiation, the strength approximately doubles.

A big advantage of working with a family of materials is the fact that properties can be varied over a wide range to suit requirements.★



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Missile Business

By Seabrook Hull

A DECISION ON WHO GETS WHAT in the way of big missiles is due within weeks—by the end of September in fact. Announcing the results of the evaluation now under way will be the first major missile action of the new Secretary of Defense, Neil McElroy. The currently appointed evaluation committee consists of Defense Department missile czar Wm. H. Holaday, AF ARDC Ballistic Missile Division chief, Maj. Gen. Bernard A. Schriever, and Maj. Gen. John B. Medaris, head of Army Ballistic Missile Agency. The latter two officers and their respective panels of experts are currently studying each other's knowhow and achievements. The original date for settlement was, until recently, October 15, but a variety of factors—deteriorating interservice politics; the international need for the West to have operational ballistic weapons at the earliest possible date—have forced a decision to be made sooner. As a result, a crash program has been instituted. Congress, the Defense Department and General Schriever & Co. have paid extensive visits to ABMA in an attempt to find out just exactly what is going on in the missile field.

FACTORS AFFECTING *JUPITER-THOR* DECISION are many and sometimes conflicting. On the record to date, *Jupiter* is the superior system: it has flown its design distance three times; its guidance has demonstrated a suprisingly high degree of accuracy. Despite its troubles, AF has consistently called *Thor* a production missile and has expended considerable funds on tooling, etc. If the decision is for *Jupiter*, as it appears it must be, *Thor* production facilities can be turned over to other projects—or Douglas might be appointed "second source," though it's doubtful if the volume of the order would justify this.

ONE OR THE OTHER MUST BE CHOSEN. This is certain. A combination is impracticable. The only part of the two systems that is common to both is the NAA liquid-propellant motor, and in each case this is completely trouble-free. Aerodynamic configuration, guidance, control, warhead, etc., are all different for *Thor* and *Jupiter*. A missile is a highly integrated system. This comes only with the expenditure of money and time. Starting anew, for example, to work *Jupiter* guidance in with *Thor's* control system, would dangerously delay operational IRBM.

THE NOD WILL GO TO *JUPITER*. At least this will be the case for this country's earliest IRBM. Later versions may combine both *Thor* and *Jupiter*, but any effort to combine the two systems now will only serve to delay the time when this country will have an IRBM by many months, if not years. Whichever way the decision goes, somebody will be embarrassed—either AF or Army. The basic national need for a usable weapon in this category is so great that politics, etc., will be laid aside.

BRITAIN WILL BUILD ITS OWN LONG-RANGE MISSILES. Tip-off is licensing agreement between NAA Rocketdyne and Rolls-Royce for RR to build large liquid-propellant engines. In fact, this could have been guessed. Britain cannot afford (politically) not to build big weapons.

CLEAN-UP OF CONTRACT PROCEDURES continues as Congress questions recent military service practice of terminating contracts "at the convenience of the contracting authority." Between Jan. 1, 1954 and April 30, 1956, of the 13,711 contracts terminated, 91 per cent were terminated under the convenience authority. Of the 13,711 contracts (worth nearly $4 billion) terminated, 12,502 employed the special authority. House Military Operations Subcommittee considers that this special termination authority has been overused by Army, Navy and Air Force.

PROGRESS PAYMENT ALLOWANCES HAVE BEEN CUT on all price-type contracts. These are being cut back in an effort to minimize the effects of military spending program reductions. Defense Department directive, detailing new formulas for progress payments, is No. 7800.5. It applies primarily to new contracts, though those in force now with optional clauses will be adjusted downward accordingly.

HOT COMPONENTS

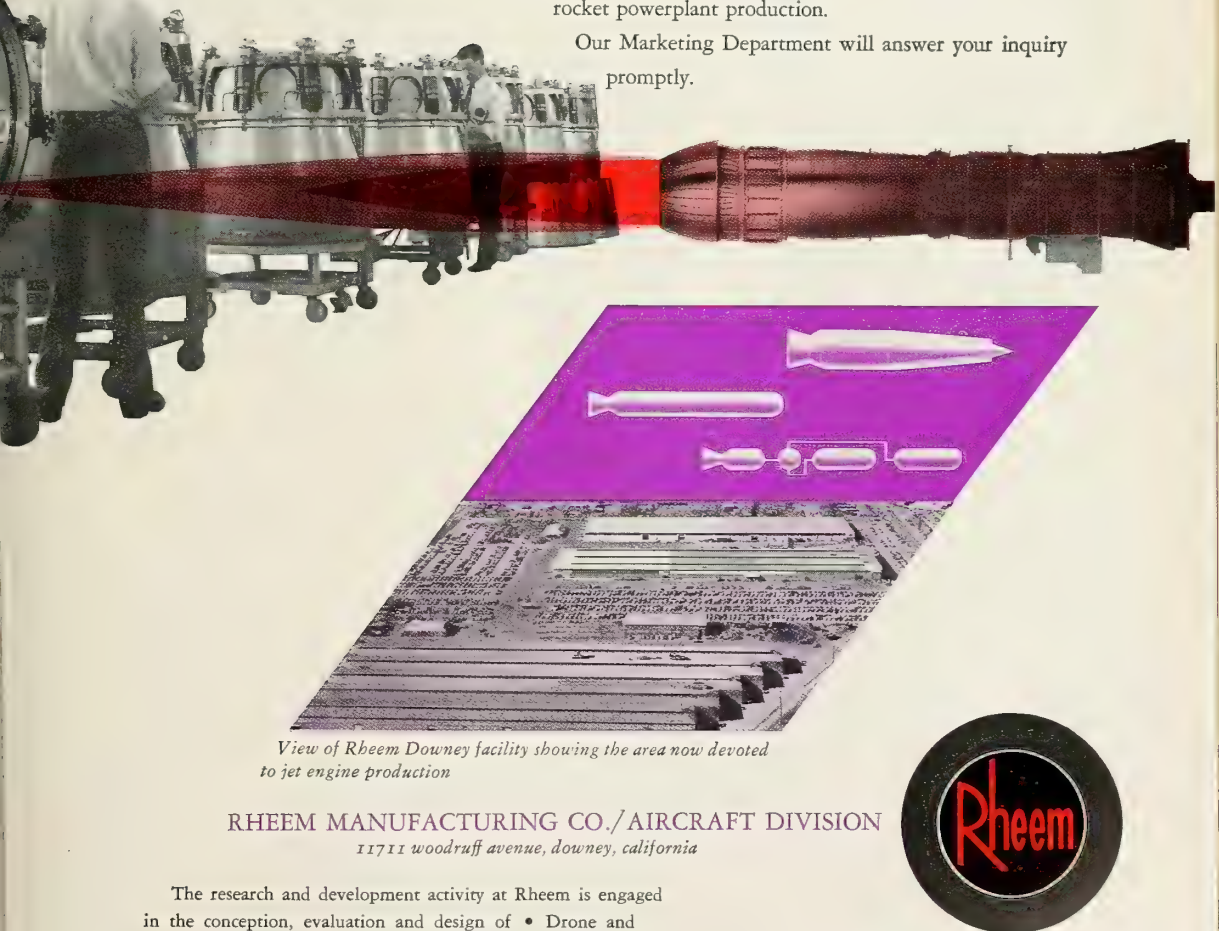
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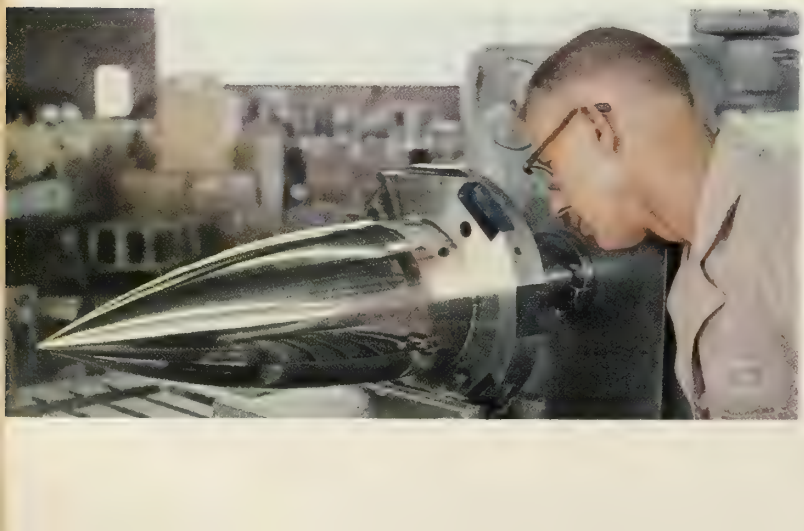
missile production

Photography by
Art Papke and E. Hull

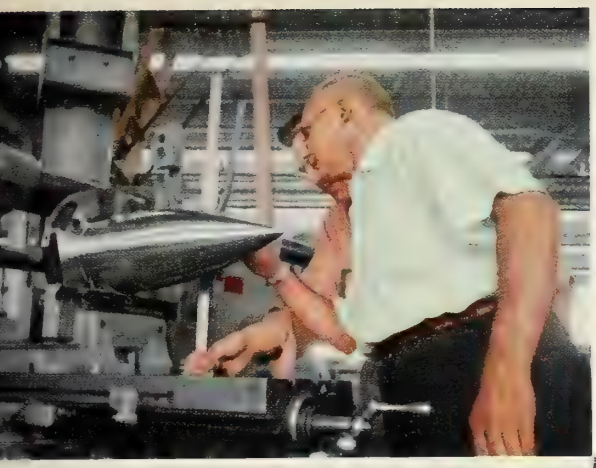


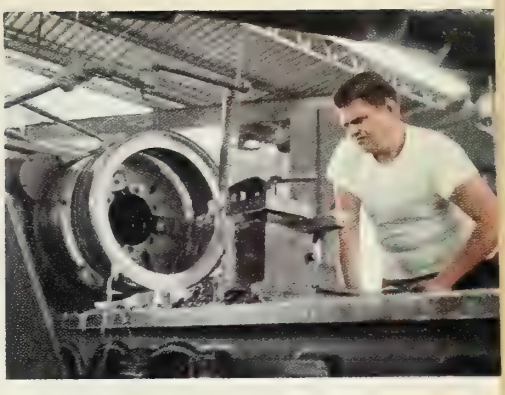


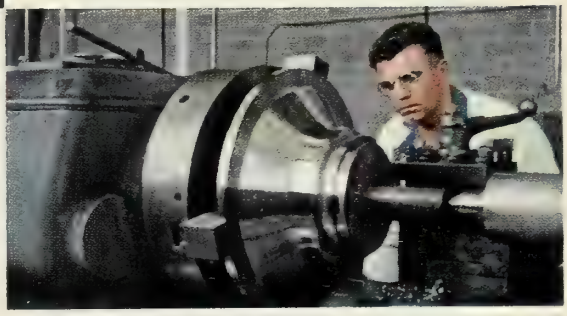
Machining for Missiles



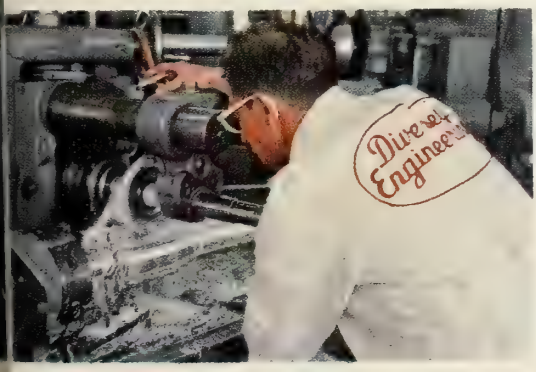
The greatest single need in missiles today is producibility, repetitive-but-reliable mass production of complex close-tolerance parts. A curse and a beauty of missiles and rockets is that they are not like airplanes—a curse because we now try to build them as though they were; a beauty because, we start to realize, we don't have to. Once the first design tangles are out of the way, missiles are susceptible to the same kind of production knowhow that works so well for highly competitive consumer products. This means: The expensive, exotic, sophisticated, often preposterous missile of today is subject to cost-cutting techniques never yet available to military aircraft. It takes some getting used to, but is beginning to be applied at the bits, parts and pieces level. And what the vendors and subcontractors have begun will become common to the whole industry—for they now figure on trying for some missile systems contracts







To the left, J. H. Kauffmann, President, Diversey Engineering Company, Franklin Park, Ill., admires the dye mold for a HAWK nose cone. . . . Beyond, a solid propellant rocket nozzle is checked for surface finish—16 microinches on production items is not unusual, attained in the regular machining operation without additional polishing. . . . The smaller dye mold in this series is for the SPARROW. Immediately below, the core mold for a solid propellant rocket motor requires intricate close-tolerance tapered contours . . . while above right, Monarch air tracer lathes, a mainstay of missile metal machining, cut missile adapter rings out of solid stock. Plus-or-minus one thousandth of an inch over a 24 inch diameter, is a standard missile tolerance. Missile metals range through the temperature series from aluminum to molybdenum. Repetitive near-automatic machining is a must. New tools are being devised, as often by the machine tool user as by the manufacturer. Missile machining is highly competitive. New methods are being perfected, and certain aspects of missile production begin to take on the air of a Detroit assembly line. Of the 15 missile machining companies in the country, Diversey, which also does rocket motor assembly, is largest.









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Astrionics

By Henry P. Steier

The Army has done it again! Recent "mail delivery" flight of *Jupiter* missile points up delivery accuracies achievable with Army's basic guidance system technical philosophy. The flight "delivered" a letter to Maj. Gen. Medaris, Commander, Army Ballistic Missile Agency.

After a flight to a couple of hundred miles altitude, and covering a range of about 1200 miles, the missile reportedly fell within a predicted 400-yard circle and the letter was easily recovered.

Not bad! And, it brings to mind the undercover war that has been waged between Army and Air Force guidance experts on relative merits of air-bearing versus hermetic-integrating gyros (liquid-floated to cause rotor weightlessness) as sensing elements in inertial guidance systems for Army's *Redstone, Jupiter* missiles and AF's *Atlas, Thor, Titan,* missiles.

Army's marriage to air-bearing gyros probably reflects strong influence of gyro philosophy held by German scientists in Army's employ. The philosophy began with design of German V2 during World War II. V2 used air-bearing gyros. Basic idea of using air for a bearing is to reduce friction at the bearings supporting the gyro rotor and thus remove error induced by unwanted friction torque.

On AF side Ramo-Wooldridge Corp. is reportedly pushing use of HIGs as the answer. However, rumors state R-W believes HIG gyros supplied by Minneapolis-Honeywell are "too good". They *are* good, and apparently are the mainstay of inertial navigation systems for aircraft where problems are somewhat different than in missiles.

Some indication of reliance the AF is placing on its gyro philosophy is indicated by recent reports of a switch from radio-inertial to pure inertial for the *Atlas. Titan* reportedly also uses pure inertial, although the *Thor* is radio-inertial.

Attack on the basic parameters of bearing friction was begun by Sir Isaac Newton near the end of the 17th Century. Newton learned some basic facts when he experimented with resistance to motion of two concentric cylinders turned relative to each other while submerged in a liquid. He observed that for a constant temperature, the frictional force was proportional to the speed of rotation and to the swept area, and inversely proportional to the radial clearance between the cylinders, providing this clearance was small. The equation Newton got from this theory was demonstrated to be accurate when applied to air-lubricated bearings by Albert Kingsbury, an American, in 1897.

Surprisingly, top-quality air-lubricated bearings can be purchased at the local drug store. Dry hypodermic syringes are excellent journal bearings that run very well with air as a lubricant under ordinary hydrodynamic conditions. When air is introduced into bearings hydrostatically at elevated pressures, load carrying ability is very good.

Some basic papers on air and water bearings in the 1941-1945 period work of the Institute for Technical Physics at the Technical Higher Institute, Darmstadt, Germany indicate intense German interest in such bearings for gyros during the war. These probably influenced V2 design and seem to be still influencing U.S. designs. Sperry-Gyroscope was a major early producer of air-bearing gyros in the U.S. and still produces them through its Ford Instrument Co. division for the *Jupiter*. Just recently, Sperry began production of HIG type gyros of latest design for AF navigation systems.

Whatever comes out of the "gyro-war", the Army has established a very handy standard of reference with its recent *Jupiter* flight and the results should be interesting to watch.

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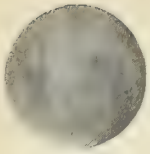
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Missile Miscellany

How miscellaneous can you get! Defense Department learns of Army's year-old ability to launch a satellite with off-the-shelf hardware and issues direct order to ABMA's Gen. J. B. Medaris not to do so; dispatches auditors to Huntsville to see how Army missile money's being spent—and likes $29-million Vanguard to an admitted $110 million. AF telephones in cancellation of Navaho—cost to date, $690 million—and "dead" bird makes perfect Mach 2-plus flight. ARDC officially defines space flight as dirty word; orders its Office of Scientific Research to deny any-and-all contemplation of moon rockets—then puts on gala show for AF Ass'n meeting that's all space flight, including spacemen spielers in passionate pink uniforms and star-gazing quotes galore from AF generals. And now a $139-million production contract for Bomarc even though missile's yet to meet design requirements for operational reliability at range. Your turn, Mr. McElroy!

And who popped up the other day but a friend asking m/r: "Why don't you glaze your articles a little bit, like other magazines do?" In reply: We roam, report and reflect and where the chips fall, we leave them. m/r's life and primary interest is the missile industry and for this reason we must serve as conscience, executioner and number one salesman. Footsy, glazing and other connivery remain the privilege of the old, established and subsidized. We don't want missile business to rust prematurely . . .

CX—This page heard wrong (it's human): Army, not AF, worked out anti-slosh devices that took teeter out of Jupiter. Even so, AF argues any combination IRBM be called Thorpiter instead of Thupiter, as suggested, because "we think we deserve more credit . . ." And further proof that there's still humor (and hope) in the missile business, a quip from Redstone Arsenal: "Retreat, Hell! Those are our rockets."

A hint to the "Surfcasting, Long-Lens and Birdwatchers League" at Cape Canaveral: Thiokol's Polaris motor has been dubbed an octopus with the bends. More on propulsion: Advances in solid thrust, mass ratio and specific impulse now under static test may result in giving current Far Side configuration moon impact capability. NACA has proposed afterburning as a way to give ramjets thrust control over a wider range. Despite all the talk, zip fueled ramjets still haven't been flown because of lack of knowledge because of lack of boranes. New production methods should hike supply; cut costs.

Any industry is made up of companies, and there, trends reveal the future: A hotshot management team's being dispatched from Ford Aircraft Engine Division to already competent Aeronutronics. And just a few miles south, NAA's de-Navahoed Missile Systems Division wins AF long-range WS-131B air-to-surface missile contract, but continues to peptalk its salesmen on fact that Army and Navy also have some missile money to spend. Meanwhile, OMAR the first of the missile "groups" lingers in a kind of suspended animation. And from an old Chinese rocketeer, vendors will become primes if they're careful and sharp; primes will become vendors if they're not. More philosophy: Reliability and producibility go hand in hand. They do. They do.

For a Full House we now have several companies working on an anti-anti-missile-missile missile . . . hyper-muzzle velocity bullets may be the best answer yet for bomber anti-missile defense . . . Polaris won't get Bob Truax (or vice-versa) after all—Gen. Schriever talked Navy into extending his AF ballistic missile tour . . . Motorola's tube rejection rate in Terrier black box assembly line was ½% compared to 10% national average and has achieved Ivory soap in-flight reliability for its units . . . careful tests by some guidance system manufacturers show contract specifications may exceed actual operational environments by 1000%—know what this costs? . . .



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Actual photo of the Honeywell space reference system designed for Project Vanguard. This Honeywell inertial-type guidance system will guide stages one and two of the Martin-designed earth satellite launching vehicles. Third stages will then cut loose to position satellites in their orbits.

Honeywell

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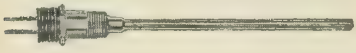
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INDUSTRY SPOTLIGHT

By Norman L. Baker

Boron Plays Lead Role in HEF Development

Niagara Falls, N. Y.—Olin athieson predicts that the production high energy fuels, demanding boron mpounds as the basic ingredient, will ach the $1-billion figure within ten ars. For a field in such short exist- ice, its present rate of growth is markable. This expensive infant, ruggling for recognition in an in- istry dominated exclusively by hydro- rbons, is emphasizing "performance fore cost." Officials in the industry e very optimistic about its future.

t Age Provides Impetus

The emphasis on boron was a rect outgrowth of the search for an eal fuel for high performance jet gines. Requirements for this ideal el are:

1) high energy content per unit eight
2) high energy content per unit lume
3) easy handling
4) low in cost

The long standing hydrocarbons, rfoming efficiently as aviation fuels, uld not meet all these requirements. ie HEFs that have been developed d recently placed in limited produc- n will encompass all these require- ents. The most important require- ment is the BTU/lb. value, which is the characteristic that separates the high energy fuels from the hydrocarbons. Aviation gasolines have a heating value of about 18,500 BTU/lb. while HEFs are in the range of 25,000 BTU/lb. It has long been known that hydrogen-carrier compounds possessed the highest heats of combustion. Liquid hydrogen, when considered for its heat content, would be an ideal fuel. This element was quickly eliminated due to its low density and the extreme difficulty in handling. Beryllium, the next element to be considered, has a heat content of 29,000 BTU/lb. This element was not very promising because it is rare and expensive to process.

Boron, with 26,000 BTU/lb., presented a much different picture. Here was an element that was very plentiful and would fit into a mass production processing operation. This nonmetallic element exists only in combination with other elements. Boron, next to lithium, is the lightest element to combine with hydrogen.

Borax Basic Ingredient

The principal source of boron was available in unlimited quantities in the compound borax ($Na_2B_4O_7$). For many years a household item, this crystalline salt is mined extensively in the U.S. and South America. The use of borax for production of HEF commands only a small percentage of the borax industry but in a few years this market could easily be the most important.

A Big Three in borax production supply the free world's needs:

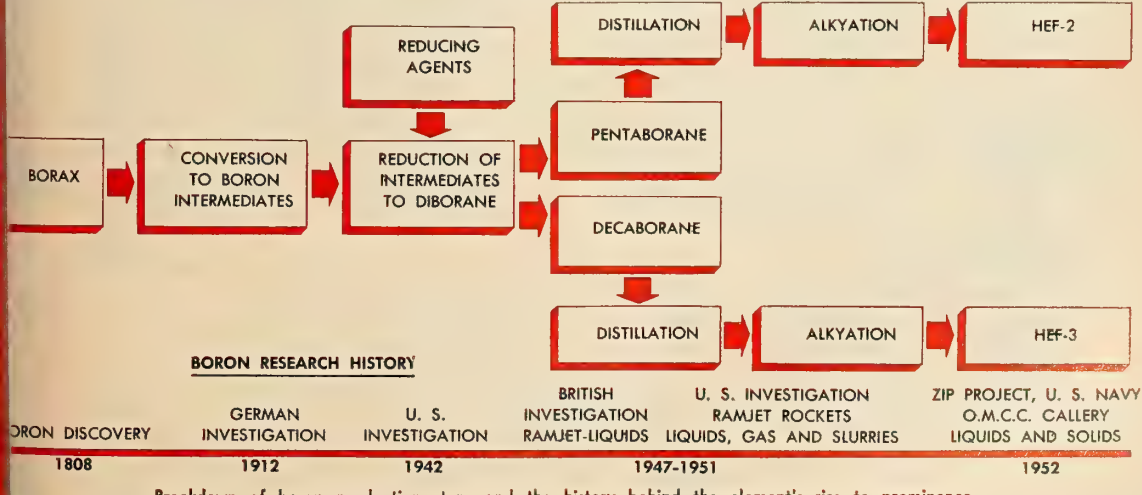
U.S. Borax and Chemical Corp. (also Pacific Coast Borax): Supplies 70% of domestic borax production. World's largest mines at Boron, Calif., contain finest deposits of boron compounds. Originally underground, mines are now open pit.

American Potash and Chemical Corp.: Supplies 20% of domestic borax production. Borax is recovered from brine deposits of Searles Lake near Death Valley.

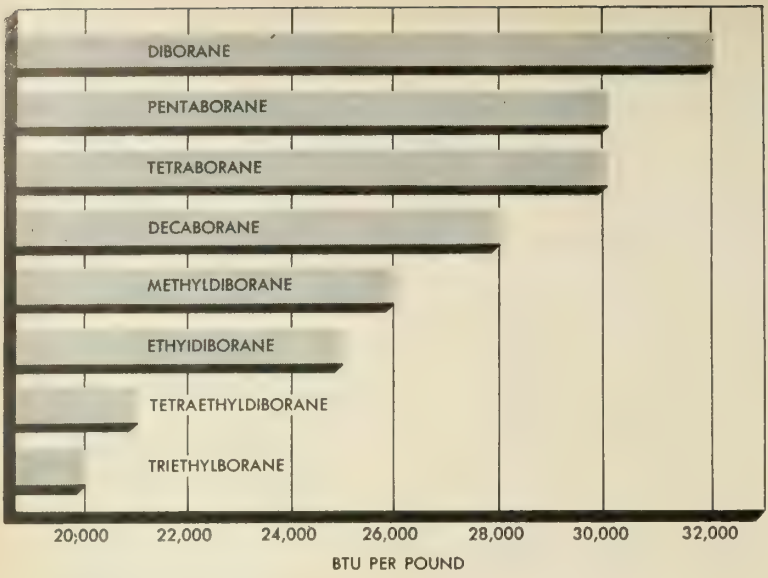
Stauffer Chemical Corp., West End Chemical Div.: Supplies 10% of borax requirements. Recovers borax from brine deposits of Searles Lake.

Intermediates Expensive

Once the basic boron-carrier compound had been found, the next step was to "alloy" the boron with hydrogen. In this way the optimum



Breakdown of boron production steps and the history behind the element's rise to prominence.



Comparison of heat output from various types of borane used as rocket propellants.

could be obtained in heat content, handling characteristics and manufacturing economy. The borax was first converted to a useful boron compound known as an intermediate. The preparation of the intermediates apparently is the more complex and expensive of the operations.

HEF producers are currently using outside purchased intermediates. Boron trifluoride, boron tribromide, and boron trichloride are the three outstanding intermediates now being used for HEF production. Leaders in the production of intermediates a Stauffer, Metal Hydrides, Americ Potash, Chemecon, Delta, Gener Harshaw, K & K Labs., Ohio Chen cal, and Pilot Engineering.

Propellant Processing

The intermediate is reduced either sodium borohydride or lithiu hydride to obtain diborane, the k borane propellant. Diborane, a gas, unsuitable as a propellant due to s bility and logistical involvements.

The processing from this stage can follow more than one route. the application of heat the dibora can be converted to either pentabora or decaborane. When deriving pen borane it first goes to the unstab form (B_5H_{11}) which then reverts the stable pentaborane (B_5H_9).

Although pentaborane has reasc able physical properties (BP 140° sp. gr. 0.61) it is possible that it w be limited to moderate speed rang due to aerodynamic heating. The so state decaborane ($B_{10}H_{14}$), on the oth hand, has a melting point of 211 and a boiling point of 415°F. The or problem here is to get it into suspe sion in the fuel.

Performance figures released Olin Mathieson, indicating a reducti of 10-20% in aircraft or missile ran

SDD needs an aeronautical engineer who might aptly be described as a specialist in the element of choice. He will be required to evaluate equipment and equipment systems for purposes of incorporation into a major nation-wide system. The position requires general familiarity with a wide range of technical subjects, including missiles, interceptor aircraft, and electronic systems, with recent specialization in at least one of these. The ability to think in broad concepts, while retaining mastery of subordinate but complex factors, is also necessary.







THE ELEMENT OF CHOICE

This engineer must be qualified to keep up with advancements in his field, through liaison with other departments and companies. Call collect or write for more information.

System Development Division

The Rand Corporation

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11-8

Getting Talos Off to a Good Start



DESIGN
ENGINEERING
DEVELOPMENT
PRODUCTION

For its initial flight, the XX*-ton Talos ram-jet missile is pushed skyward by a powerful booster rocket. In a split second from launching, internal pressures are up to XXXX* psi . . . nozzle temperatures to XXXX* F. To design and produce a unit to endure such sudden torture called for an unusual combination of specialized engineering and fabricating skills. A major responsibility for the Talos rocket case was assigned to The M. W. Kellogg Company

Since 1951, M. W. Kellogg has been closely associated with the development and production of propulsion units for a wide range of missiles. Kellogg's most recent contribution is the development of reinforced plastic for rocket cases, using a unique filament winding method which produces structures of unparalleled accuracy and light weight.

*Actual figures classified

FABRICATED PRODUCTS DIVISION

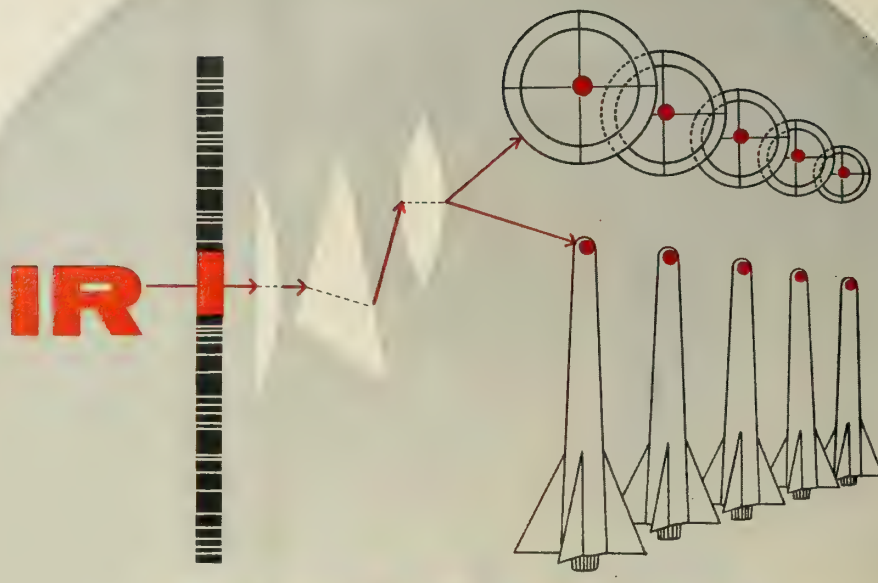
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when using HEF instead of pentaborane, could mean that their HEF is an alkylated pentaborane or decoborane. The addition of an ethyl alkyl group to the propellant would improve stability with the resultant loss in heat content.

OMCC identifies their borane propellants as HEF-2 and HEF-3. Informed sources refer to HEF-2 as ethyl alkylated pentaborane and HEF-3 as ethyl alkylated decaborane. Meanwhile, the successor to HEF-3 is ready to be phased into production.

Development History

The first synthesized HEF was submitted to the Air Force two years after initiation of a concentrated effort by industry research teams. Preliminary studies of boron began many years earlier.

Boron chemistry was first investigated in Germany in 1912. Early work in the boron hydrides was not followed up in this country until 1942. It was the Royal Aircraft Establishment in England which first initiated studies of boron as a propellant. The U.S. was soon experimenting with boron compounds for rocket and ramjet fuels. These experiments were extremely limited by a shortage of available materials.

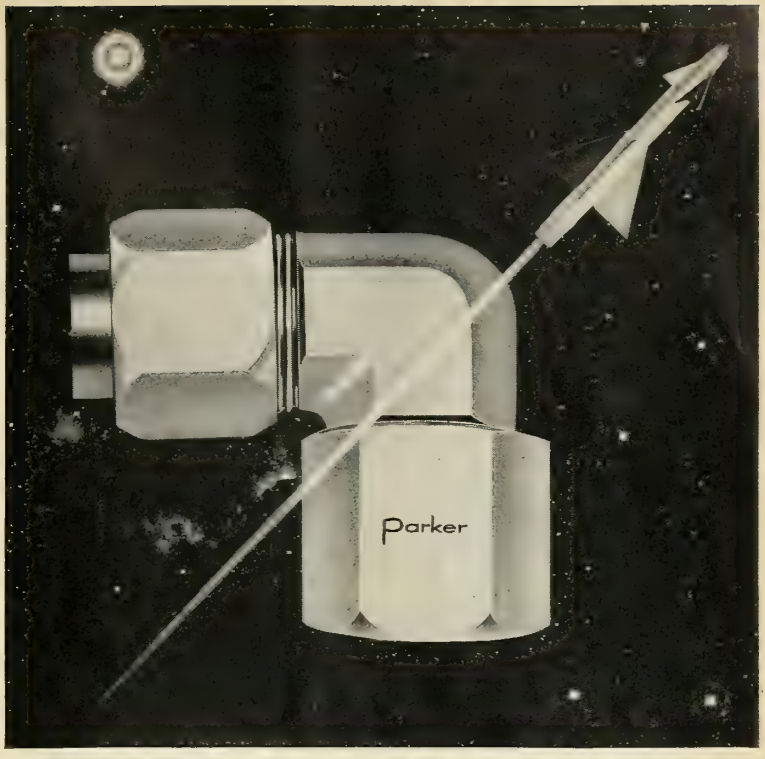
Major impetus was supplied by the Navy in 1952. Research and development contracts to Callery Chemical and Olin Mathieson for Project ZIP, gave birth to the present borane propellant industry. The project was under the Navy's Bureau of Aeronautics until 1956, when it was placed under the Air Force.

The pioneer work by Callery and Olin Mathieson has given them a lead that has not been challenged to date. American Potash & Chemical Co., classed as an intermediate producer for HEF, is also turning out the decaborane propellant. AP&C's price tag of $600-800/lb. for the propellant indicates a small scale operation at the present time. Their predicted commercial price of $100/lb. will still be too high for extended USAF consideration.

Progam Expands

Olin Mathieson's $5.5-million company-owned pilot plant at Niagara Falls, N. Y., first to produce borane propellants on a semi-commercial basis, is now making deliveries to the Air Force. A $4.5 million interim plant, under construction for the Navy, will soon go into operation. Output of this plant is expected to triple present production of borane propellants. The USAF's $36-million Model City in Niagara Falls is scheduled to be completed by early 1959.

Estimates on the capacity of the



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Model City facility vary but most sources feel that 2-3 million lb/year is conservative. Olin Mathieson officials are quick to point out that Model City is not intended as a production facility to meet completely the needs of an Air Force traveling entirely on HEF. The "limited production" plant, with 13-14 times the present borane propellant processing capability, is expected to meet the requirements of engine development. Although present fuels are being produced solely for jet aircraft development, such as the WS-110 project, officials confirm rocket engine development work utilizing HEF. Reaction Motors is Olin Mathieson's complimentary partner in the rocket research field.

The role of HEF in the liquid propellant rocket field is questionable. This, according to officials of Reaction Motors, is the conclusion reached after many years of research. Main objection is the high weight of combustion products. Although the HEF heat of combustion is an attractive feature, the heavy combustion exhaust lowers performance until it is only slightly above that of "conventional" propellants. Added to this is the high cost, toxicity, handling and availability problems of HEF.

HEF for rockets seems destined for the solid propellant role. An indication of this is the recent Air Force contract to Olin Mathieson and Reaction Motors for development of high energy solid propellants. Reaction Motors is prime contractor with a sub-contract to OMCC. Olin Mathieson will develop the propellant at its East Alton, Ill. plant while Reaction will package and test the final product.

Callery Chemical's present HEF plant facilities expansion program is on a comparative basis with Olin Mathieson, except it is under Navy sponsorship. In addition to their headquarters and operating pilot plant at Callery, Penn., Callery is building two plants for HEF output. Largest "chemical" plant, located at Muskogee, Okla., will be a $38-million Navy facility. Plant at Lawrence, Kan. will be a $5-million company financed project. Olin Mathieson's plants will devote entire output to HEF while Callery's production will be more diversified and flexible.

In 1952, when the Navy was looking around for takers of the ZIP project the petroleum people apparently were not interested. Perhaps a gauge to the future of the boron industry has been exhibited by the recent Gulf Oil Co. merger with Callery Chemical.

One thing is certain. The present cost of HEF is apparently much too high. Olin Mathieson, although not quoting exact figures, stated that their present fuel is priced considerably less than $30/lb.

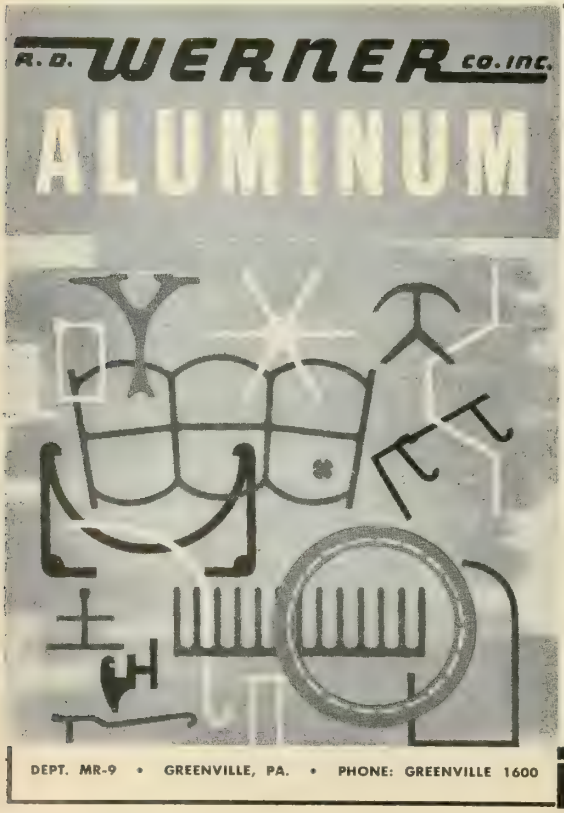
OMCC's goal of $1/lb within ten years, where reducing agent is recovered and recycled, should place borane propellants firmly and permanently in the propellant picture. A stable continued growth of boron depends upon the extent and urgency of the military's need for a better propellant.

Era Engineering Winds Up Van Test

Era Engineering, Inc., Santa Monica, Calif., has completed initial field tests on an instrumentation van constructed for Grand Central Rocket Co., Mentone, Calif.

Especially designed for use at remote static rocket motor firing areas, the unit contains electronic recording and pickup instruments, a master fire control panel, and can act as a central communication center for the test area.

The master fire control panel, a feature of the van, was developed by Era expressly for static testing of rocket motors. The panel functions to turn on recorders, cameras, calibration



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signals, the rocket motor, and then to successively turn off the same pieces of equipment.

If the test should be interrupted for any reason, it is possible to stop the sequence operation and to automatically instigate calibration checks before turning off the equipment.

The panel is also designed so that the switching schedule can be revised in the field in just a few minutes.

RMI Completes Huge Test Stand

Reaction Motors Inc. has completed, and is operating, a huge new rocket engine test stand at its Lake Denmark, N.J. facility. The stand is claimed to be the largest of its kind in the country and is believed to be the only stand in the world capable of testing engines of over one-million-pounds thrust in any flight attitude.

The stand uses retractable roof and front and side curtains, representing the latest design for test purposes. The stand was designed by RMI engineers and incorporates test and measurements equipment and closed circuit television. The control room, containing instrumentation, recording and monitoring equipment, is located several hundred feet from the test stand.

The large rotating beam, on which an entire engine assembly (including thrust chamber, pumps, regulators, tankage, propellant lines, etc.), can be mounted, is raised and lowered by a huge hydraulic cylinder.

During vertical firings, the rocket engine exhaust is deflected horizontally by a blast plate so that the energy is expended in open air. A two-stage water spray ring system has been installed between the engine nozzle and the deflector plate to cool the exhaust gases and prevent erosion.

80,000-lb. Mica Melt Announced by Synthetic

Synthetic Mica Corp. has produced the largest commercial melt of synthetic mica yet attempted. The company says it used 80,000 lbs. of raw material in the process. After approximately three weeks of cooling, the company broke up the mass of crystalline Mica and will grind or split it into usable form.

The company is conducting research toward producing larger area crystals in great volume. Crystals as large as 4" x 4" have been produced consistently.

Developments are being watched with interest by government agencies and manufacturers of high-temperature electrical and electronic equipment.

ROCKET POWER PROGRESS REPORT

Servicing Rocket Engines

Part I: Know-How

by Fred Barker



Supervisor of the Product Service Department at Reaction Motors, Inc., Mr. Barker coordinates the activities which keep rocket engines on their good behavior. A graduate of New York University, with a B.S. in M.E., he has had diverse experience in engineering—including test, manufacturing liaison and customer service liaison. Mr. Barker joined RMI in 1949.

"Know-how" in any business is the result of thorough training and experience on specific products. RMI Product Service Department personnel get a complete grounding on their products right from the development stages through field installation and operation. The know-how thus attained is turned into a direct benefit for all RMI customers.

Key service engineers and service representatives join a project during early development, work actively with Engineering, Component Development, Assembly, Test and Inspection Departments. Mock-ups are reviewed from the standpoint of service—i.e., whether proper consideration has been given installation, accessibility and serviceability of components and the overall powerplants.

When a project is ready to move into the field, these same key men act as instructors, conducting training programs to impart their accumulated knowledge to customer personnel and other service representatives. With our ROR powerplant (rocket-on-rotor for helicopters), for instance, Sikorsky, Navy and Marine Corps personnel attended training programs at RMI and in the field. Scope of these programs covered the rocket powerplant, its installation and operation in the Sikorsky HRS helicopter, and the use, transfer and storage of the hydrogen peroxide propellant. Once ROR settled into operations at the Marine Corps Air Station, Quantico, Virginia, the service representative's know-how assumed a stand-by character. Training programs were repeated or amplified only as required by personnel changes or powerplant modifications.

Safety is a major item in each RMI representative's assignment, because safe use of the powerplant and safe handling of propellants are of paramount importance. Safety is improved by service representatives through on-the-spot lectures and training programs, whereby procedures and policies are outlined and integrated into the activities routine. Again, at Quantico, an admirable safety record has been achieved and maintained in just this fashion. There, over the past few years, our service representative has assisted the Marines in safely utilizing the ROR powerplant and the hydrogen peroxide fuel for their HRS helicopters. The result is found in the simplicity of powerplant operations, peroxide handling and storage area procedures, and in the attainment of a "no personnel injured" safety record.

Obviously, know-how is of importance in a clutch situation. Wisely applied, it leads to the right decision and the proper corrective action on the scene of a problem. The recently launched Glenn L. Martin No. 13 Viking missile provides a case in point. Pre-static firing inspection revealed discrepancies in some components of our 20,000-pound thrust rocket engine. Normal field maintenance sufficed for all but one difficulty: a valve seat and poppet, scored by foreign material, required lapping to meet leakage specifications—but no lapping compound was on hand. Our service representative used common household cleanser, lapped the poppet and seat to within leakage specifications, and the program moved on with only minor delay. This difficulty remained minor only because prompt and proper handling prevented development of a major program obstacle. Immediate action was required; immediate action was taken.

In Part II, we shall examine the function of the service engineer and service representative in various areas of Product Improvement.

If you desire one or more reprints of Mr. Barker's article, or would like to receive further information about employment at RMI, write to our Information Services Coordinator, Reaction Motors, Inc., 16 Ford Road, Denville, N. J.



#1 in a series . . . on

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For a missile to realize its inherent reliability factor every system component must "be in tune." The burden of sensitive and complex electronic functions multiplies the problems. The inadequacy of conventional electric cabling, using standard jacketing concepts, is now recognized. Hence there has arisen the demand for "cable-tronics"—the new systems design concept of *true electronic cable structures* to meet specific requirements.

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Major *Bomarc* Contract Awarded Boeing

The first large production contract for the *Bomarc* surface-to-air missile has been awarded to Boeing Airplane Co. Latest contract, from fiscal 1957 funds, totals $139,315,444. Contract will support limited quantity production of the tactical area defense missiles.

The initial production contract of over $7 million, released in May of this year, covered tooling-up operations. *Bomarc* will be assembled in Seattle while the major portion of manufacturing will be handled by subcontractors.

Reports that the *Bomarc* has been plagued by design problems may be related to the recent decision to switch boost systems. Later models of the missile will employ a solid propellant booster motor in preference to the Aerojet liquid engine now being used. One outstanding design feature, apparent in the recently displayed *Bomarc* missiles, was the performance-limiting integration of the boost system to the sustainer portion. The solid propellant booster (if droppable) will undoubtedly increase the range, altitude and velocity of the missile.

Missile Spending Exceeding 1957 Estimate

Military spending for missiles as of May 31 has surpassed the fiscal 1957 estimate. The services spent $1,868,000 for missiles—$362,995,000 more than the $1,506,000,000 planned for the period.

Service breakdown for the 11 month period and an estimate of total spending for fiscal 1957 is:

	11-Month Actual	Total 1957 Estimate
USAF	$1,261,138,000	$860,000,000
Army	374,368,000	425,000,000
Navy	233,489,000	221,000,000

Stavid Earnings Up 13%

Stavid Engineering Co. earnings for the first six months of this year showed a 13% increase over the same period in 1956. The company reported a total of $110,826 for 1957 compared to $86,524 last year.

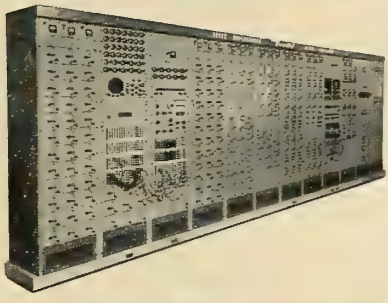
The firm expects their present backlog of orders to increase from $11 million to $13 million by the end of the year.

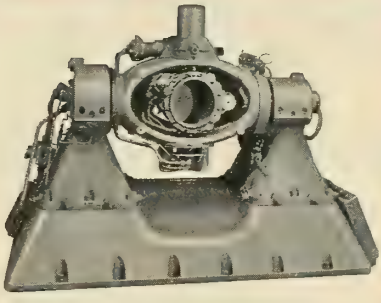
Page & Rixon Separate

All interest in Rixon Electronics Inc. has been sold by the officers to Page Communications Engineers, Inc. All Rixon common stock held by E

missiles and rocke

Bendix flight simulators reduce the risks







The hazards of missile testing can be materially lowered when performance is checked out on-the-ground with a BENDIX 3-dimensional Flight Systems Simulator, prior to take-off. Comprised of two basic units—a flight table and an electronic analog computer—the BENDIX-built Flight Simulator will foretell complete operating programs from launching pad to target, for rockets, ballistic and guided missiles and jet aircraft. It catches bugs without expensive trial flights, materially reduces guesswork and adds a valuable safety factor at both ends of the test shot. *For complete technical data, mail the coupon.*

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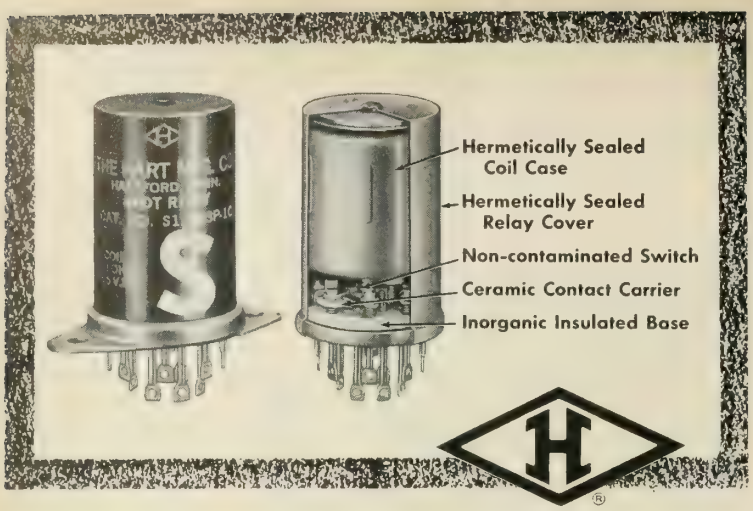
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New 'Diamond H' Series S Relays Doubly Dependable

in dry circuits

Separately sealed coils isolated from completely inorganic switches within their hermetically sealed cases make these new "Diamond H" Series S aircraft type 4PDT relays supremely reliable in dry circuits.

Physically and electrically interchangeable with "Diamond H" Series R relays, widely used in guided missiles, computers, jet engine controls, automation control systems and similar critical applications because of their broad range of performance characteristics, Series S relays will permit intermixing of dry and wet circuits safely.

Contacts are specially processed and cleaned before assembly; subsequent contamination from gases off the coil insulation is prevented by the coil seal. The switch mechanism has been simplified and is completely inorganic to eliminate other possible causes of malfunctioning.

Standard contact ratings include 30 V., D. C.; 115 V., A. C.; 2, 5, 7-1/2 and 10 A., resistive; 2 and 5 A., inductive, with special ratings available to 350 V., D. C., 400 MA, or other combinations including very low voltages and amperages, or amperages up to 20 for short life requirements. Coils are available with resistances of 1 ohm to 50,000 ohms. Operating time of 24 V. models is 10 ms. or less; dropout less than 3 ms.

Vibration resistances range from 10-55 cycles at 1/16" double amplitude to 55-2,000 cycles at 20 "G"; operational shock resistances to 50 "G" plus, and mechanical shock resistance up to 1,000 "G". Nine standard mounting arrangements, plus a ceramic plug-in socket, are available. The unit displaces only 1.6 cubic inches, excluding terminals.

"Diamond H" engineers will be happy to work out a variation to meet your specific requirements. Tell us your needs . . . or write for bulletin on new "Diamond H" Series S relays.

THE HART MANUFACTURING COMPANY

161 Bartholomew Avenue, Hartford, Conn.

terly C. Page, Joseph A. Waldschmitt and John Creutz was sold to James L. Hollis for an undisclosed amount. Until the time of the sale, Page had been president of Rixon.

Hollis was formerly executive vice-president and general manager of Rixon while it was a wholly-owned research and development subsidiary of PCE, and now owns all the common stock of the company. Completing the separation of the two companies, Hollis sold his stock in PCE and resigned as an officer and director.

Merger Announced By Radioplane & Northrop

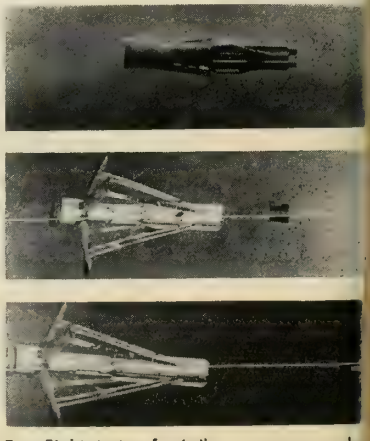
Radioplane Co. has been merged into Northrop Aircraft, Inc. and will be operated as a line division of the parent company. Northrop acquired Radioplane in 1952 and had operated the Van Nuys firm as a wholly-owned subsidiary until now.

Under the realignment, Radioplane will operate under its own group of division officers and will have separate profit-and-loss responsibility. M. W. Tuttle, Radioplane vice-president and general manager, will continue as operating head of the division.

New Firm Cleans LOX Parts

Decontamination, Inc., a new division of Consolidated American Services, Inc., has been formed in Culver City, Calif. The company is a western subcontractor engaged in cleaning liquid oxygen fuel system parts for rocket motors.

Nose Cone Model Tests



Free-flight tests of missile nose cone models are conducted by GE through use of the separation device. Fired from a five-inch gun, the device extends flaps into the air stream, allowing the nose cone model to continue in free flight. This same principle may be applied to large-scale free flight.

Circle No. 87 on Subscriber Service Card.

Reaction Develops Liquid Package Unit

MISSLES AND ROCKETS has learned reliably that Reaction Motors Inc. has developed a "package" liquid propellant rocket system. The Navy has expressed considerable interest in the system as a competitor for solid propellant systems.

Essentially, the system will include propellant tanks, pressure system and rocket engine. Operation of the unit will be the ultimate in simplicity. Components common to the present complex liquid systems have been eliminated. There will be no hydraulic lines, pumps, turbos, or valves. A simple flow actuator will be the only moving part. Propellants are hypergolic, eliminating the need for an ignition system.

Major feature of the system is its capability to provide a constant total impulse. Other features include safe handling characteristics, cost competitive with solid propellant systems and a long storage life. In addition the missile design engineer has the option of incorporating the power package either as a fixed or replaceable item.

Reaction Motors initiated the project in 1952. As far as is known RMI is the only company working on this type of project. Apparently the Navy's interest in the program has supplied the necessary incentive for RMI to continue development. Units developing up to 10,000 lbs. thrust have been test fired while a high thrust *Polaris*-type missile system is within the present range of development feasibility studies.

Martin Employes Plan Space Vehicle

A manned space vehicle is being planned by the members of the Martin Astronomical Society. Mainly an educational program, the project is a feasibility study which is expected to involve "some of the engineering areas which will be coming to the fore in this industry during the next 15 years."

The society is composed of Martin personnel who devote their own time to a variety of after-hours programs. Eventually, it is planned to extend the membership beyond company employes.

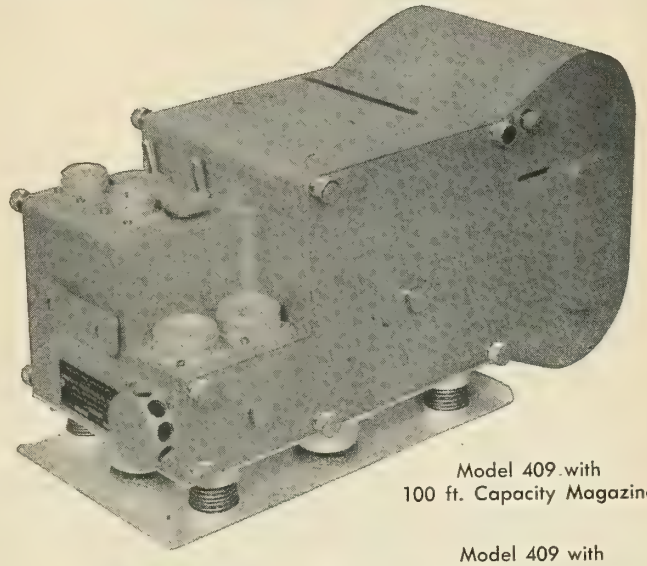
New Field Office For Lord Mfg. Co.

Lord Manufacturing Co. has opened a new field office in Kansas City, Mo., to provide sales and engineering service on vibration and shock control problems.

Century MODEL 409

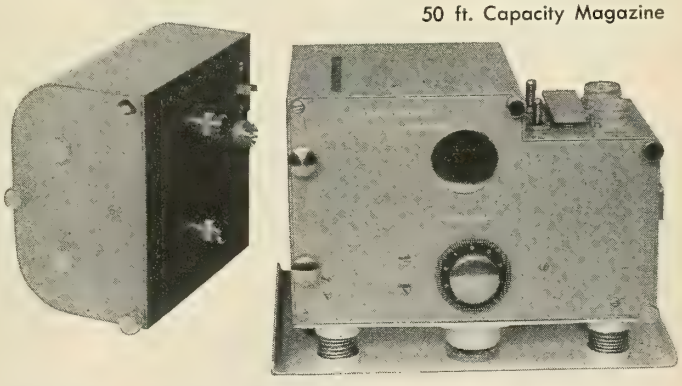
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Model 409 with
100 ft. Capacity Magazine

Model 409 with
50 ft. Capacity Magazine



The Century Model 409 Oscillograph was designed for operation under the most adverse conditions and more especially, where space and weight considerations are limited.

This Oscillograph is one of the smallest and most compact units available on the present market, yet it incorporates many features found in larger oscillographs, such as trace identification, trace viewing, continuously variable paper speeds and others. The Model 409 Oscillograph has been tested and proven to record faithfully during accelerations in excess of 20 g's. This makes it especially desirable for uses such as missile launching, parachute seat ejection, fighter aircraft and torpedo studies.

Write for Bulletin CGC-303 and CGC-301

Century Electronics & Instruments, Inc.

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GE Says Transistor Sales Might Hit $1 Billion

A General Electric executive has predicted that annual sales of transistors and other semi-conductors could reach $1 billion within the next ten years.

James H. Sweeney, manager of marketing for GE's semi-conductor products department, said that sales of transistors and similar components have risen so fast in the last few years that they have continually outstripped even the most optimistic market projections.

Sweeney noted that the main reason for the great increase in semi-conductor use is the military application of the component. Nevertheless, the GE executive ruled out any complete replacement of electron tubes by transistors, pointing out that electron tubes, transistors and other semi-conductors would probably work side by side in many future pieces of equipment.

Marquardt Delivers First Production Ramjet

Marquardt Aircraft Co., Ogden, Utah, has delivered the first production ramjet for the *Bomarc* missile. Described by the Air Force as the first ramjet engine to be manufactured with production tooling, its delivery was made one month ahead of schedule.

The *Bomarc* uses two of the 28 in. engines to propel the missile to a velocity in excess of Mach 2. Ignition velocity is supplied by an Aerojet liquid propellant rocket engine.

Marquardt has received an additional $12 million Air Force contract for continued production of the *Bomarc* engines. This brings total contract value for the Marquardt Ogden plant to $30 million.

General Dynamics Sales Increase 75% Over 1956

Net sales of General Dynamics Corp. during the first six months of 1957 showed a 75% increase over sales in the same period last year, going from $414,443,947 in the first half of 1956 to $726,081,499 this year.

General Dynamics, which topped the billion-dollar sales mark for the first time in 1956, reported its estimated backlog of unfilled orders as of June 30, at $1,989,000,000. In addition, about $654,000,000 in contracts were under negotiation as of June 30. General Dynamics expects that net sales and net earnings for the entire year of 1957 will substantially exceed those of the record year 1956.

The directors of General Dynamics and the Liquid Carbonic Corp. approved in principle a transaction in which Liquid Carbonic would become a division of General Dynamics. A company spokesman described the chemical field as a "most logical" extension of Dynamic's present activities.

American Lithium Given Study Contract

The American Lithium Institute has been awarded a contract by the Materials Laboratory of ARDC to investigate, analyze and consolidate detailed data on the physical, mechanical and chemical properties of lithium and its compounds.

Martin Sales Top $209 Million

The Martin Co. has reported a six month sales figure of over $209 million for the period ending June 30, showing a considerable increase over the total $138 million in sales during the same six-month period of 1956.

Matador Contract Awarded

Siegler Corp. has received a $1.5-million order for miniaturized magnetic autopilot amplifiers to be used on late-model *Matadors*. The Martin Co. placed the order with Siegler's Hallamore Electronics Div.

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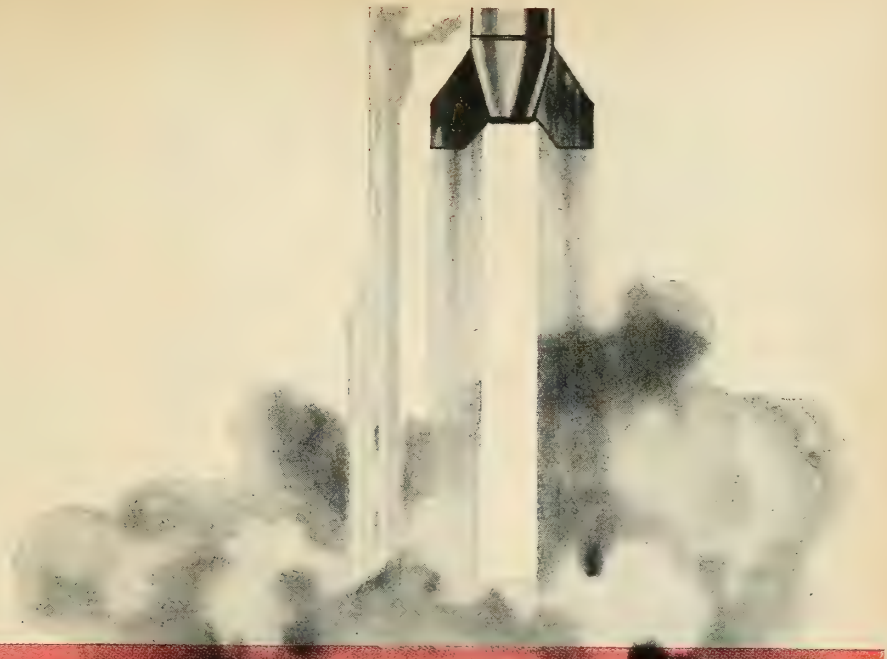
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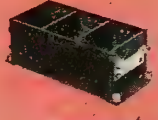
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Borg-Warner Corp. Opens New Test Lab

Borg-Warner Corp. has placed its new electronic performance and environmental test laboratory into operation at Santa Ana, Calif. The lab will be used to provide environmental conditions for the critical operating examination of electronic and electro-mechanical devices and complete systems.

The new lab includes equipment capable of simulating environmental conditions of 150,000 feet in two minutes, with temperature maintained throughout the range of −135°F to 375°F, 70 g peak vibration from 5 to 2000 cps, and shock tests of 18,000 force lbs. with any desired wave form.

Computer Plant Expanded By Bendix

Computer Division of Bendix Corp. has doubled the size of its manufacturing facilities. The expansion is expected to enable the firm to produce 100 more machines annually.

Cylinder Contracts Awarded Weatherhead

Weatherhead Co. has been awarded two contracts by Consolidated Western division of U.S. Steel for manufacture of missile cylinders. The two contracts, calling for expenditures of over $547,000, are for launching-rail decelerator cylinders and launcher-down latch hydraulic cylinders, to be installed on *Nike-Hercules* launchers. Weatherhead also manufactures accumulators, hydraulic and fluid system components.

Aeroquip Corp. To Produce LP Hose

Aeroquip Corp. has been granted production and sales rights by the Weatherhead Co. for a new permanent type of fitting for hose connections. (See New Missile Products.) The royalty-paying agreement was concluded at the same time as an agreement allowing Weatherhead to produce and sell the "super gem" reusable type teflon hose fitting.

Los Angeles Plant Slated for Technicraft

Technicraft Laboratories Inc. has purchased a ten acre industrial site in the Los Angeles area and plans to begin construction immediately. The company expects the first production shipments to be made from the new plant in January 1958.

RMI Apprentice School Ups Enrollment

Reaction Motors, Inc. has expanded its machinist apprentice program enrollment from the 20 original students to 33 in the class entering last July. The four-year course in extreme-precision machine skills is expected to supply RMI with ". . . highly skilled shop labor, which is just as scarce as—and just as important as—engineering personnel."

The program, which was initiated in July 1956, provides for about 8000 hours of training, of which 6800 hours are on-the-job training and 1200 hours are related classroom instruction. RMI accepts applicants on a competitive basis from outside candidates or from within the company.

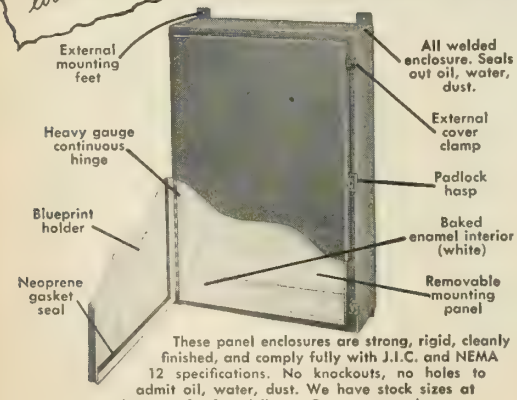
After entering the program, students are expected to turn out work that is equal or superior to work of journeymen. Course work is graduated instruction of increasing difficulty.

Although students have no obligation to RMI after graduation, the company expects to retain enough graduates to make the program a worthy one. After receiving certification of Class A Machinist, students may earn an experimental machinist's rating with an additional 9 to 15 months experience.

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IBM Computer Aids *Titan* Design

The Martin Co. recently demonstrated its newly-installed IBM 704 computer which will aid in design of the *Titan*. The unit is the same as that installed in the *Vanguard* computing center.

The company's computer, most advanced of the high-speed electronic computers developed by IBM, is not a single-unit machine but a group of electrically-connected units.

Talos "Automat" System To be Developed by GE

General Electric Co. has been awarded a $5-million contract for development of a shipboard handling and launching system for the *Talos* SAM. The "automat" system will work somewhat like "pigeonhole parking" in that the missiles weigh as much as, and are as long as, two automobiles.

The equipment must be able to automatically select whichever type of missile the fire control officer chooses by pushbutton, and deliver it rapidly to the launching station.

The equipment's control system is more complex than that used in area telephone switchboard systems because not only must the system remember which missile is in what rack, but must also remember any changes in the racks themselves.

This is GE's first contract for missile handling systems. The final product is expected to weigh more than 350 tons and require space enough to hold ten freight cars. The first naval vessel to carry the new system will be the cruiser *USS Galveston*. Planned operational date for the ship is 1958.

Narmco Builds New R&D Center

Narmco, Inc. has begun construction on the first phase of a million dollar industrial research and development center in San Diego. Completion of the facility is expected by December, and it will be utilized for work on structural adhesives, reinforced plastics and sandwich-type structures.

Convair Expands European Sales Force

Convair Division of General Dynamics Corp. will expand its European sales office in Geneva, Switzerland. The office will be managed by George C. Prill.

Chance Vought Sales Rise Sharply

Chance Vought Aircraft, Inc. has reported sales of aircraft, missiles, parts and services aggregating more than $86 million, compared with over $51 million in the same period of 1956.

The backlog of the company's unfilled orders stood at $467 million as of June 30. In a statement to stockholders, the firm said that the present economy considerations of the government "should have no appreciable effect on current operations and management believes that its previous estimates of future business activity will not be materially affected."

McLean Names Agents

McLean Engineering Laboratories have appointed several groups of representatives to handle the McLean line of electronic cabinet cooling fans and blowers in the eastern half of the country.

Technical Instruments, Inc., of Waltham, Mass., will represent the firm in the northeastern states: The Kenneth E. Hughes Co., of Union City, N.J., will cover the middle Atlantic states; and W. A. Brown & Associates, Inc., of Indian River City, Fla., will cover the southeastern states.

NEW *Harmeco* PURAFLO FILTERS

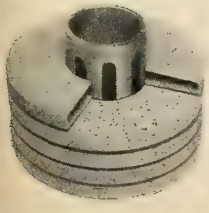


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Double tapered one piece Harmeco hollow sintered bronze disc elements provide deep uniform, dependable filtration. Spacing between the discs is uniform when assemblies are stacked and sealed in ported manifold pipe. One piece element design eliminates slip fits or organic bonding materials. The double tapered, hollow disc design prevents blocking off of surface area due to possible cocking of the elements on the manifold pipe. Result: greater filtering area; uniform porosity control; clean decontaminated products.



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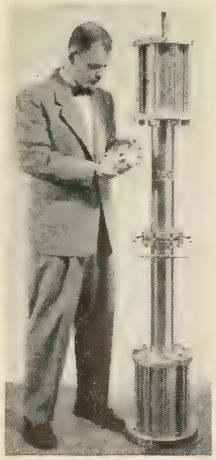
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The Hi-Torque design is a NAS Standard. Bolts in all diameters feature excellent "head to thread" balance, close recess tolerance control, tension allowables comparable to internal wrenching bolts without the attendant weight penalty, and a recess which may be machined into any steel or alloy. The Hi-Torque recess is of self-locking design and increased torque increases the driver locking action thereby eliminating axial loads and accidental driver slippage. This recess always provides positive removal.

* Superalloys such as A-286, Inconel X, S-816, M-352, J-1570, Inconel 700 and Haynes 25 are now available in the Hi-Torque configuration. Precipitation hardening stainless steels—AM 350, 17-4PH and AM 355—are also available.

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Cooper Conducts High-Altitude Research

Cooper Development Corp. is engaged in Project Sunflare for investigation of radio propagation interference and is conducting rocket launchings from San Nicolas Island, Calif. The operational phase of the project began on July 1, to coincide with IGY, with the launching of a *Nike-Deacon* two stage rocket. The vehicle, carrying a 30 lb. instrument payload, rose to 80 miles and gathered background spectral data for about two minutes.

CDC is also using a *Nike-ASP* combination to reach altitudes of 150 miles. The initial data obtained will be used to establish baselines for signals recorded during later flights involving flares. A total of 14 rockets are scheduled to be fired during the project.

Since sunflares occur with virtually no warning, and may reach peak brilliance within 5 minutes after an alert, the rocket crews and scientists must be ready to fire at any moment. The CDC crews, alerted by participating observatories, have been getting the rockets off in about 60 seconds.

Military Products Group Set Up By Honeywell

Minneapolis-Honeywell Regulator Co. has made an administrative realignment of its divisions concerned with products for military use. The realignment, executed to meet the management, engineering and manufacturing needs of the military, is said to create "one of the largest sources in the country for research, engineering and production capability."

Packard-Bell To Develop Digital Computer

Packard-Bell Electronics has received a research and development contract from the Army for a high-speed digital computer to work in conjunction with equipment at the computation center at Redstone Arsenal. The digital simulator will compute the behavior of dynamic systems of missile airframes, inertial guidance and fire control devices.

Daystrom Ltd. Formed

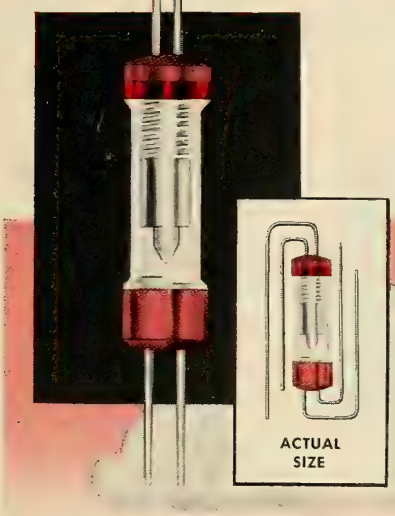
Daystrom, Ltd. has been formed in Canada to handle sales, service assembly and manufacture of Daystrom electronic products. By 1960 the company expects to have a large-scale Canadian manufacturing operation.

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Weight	Less than 0.1 ounce
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Altitude	In excess of 75M'
Shock	250 G, 2-4 MS deceleration
Vibration	20-2000 CPS, to 40G
Acceleration	150 G
Operate Time	Less than .3 second with 3-4 VDC applied
Container	Herm. sealed in high thermal-shock resistant glass container
Trigger Ckt. Resistance	1.2 ohms minimum
Contact capacity	.5 ma. to 5.0 amperes DC
Insulation Resistance	200 Megohms minimum @ 500 VDC

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Litton Industries On Stock Exchange

Litton Industries, organized in November 1953, became one of the youngest firms to be listed on the New York Stock Exchange when its common stock was called for trading on July 30. The company's common stock has been traded on the American Exchange since September 1956.

With recent establishment of an activity in Salt Lake City, Litton now is in operation at 11 locations across the country. The firm is engaged in research, development and manufacture of advanced electronics.

American Aerophysics Adds Fiberglass Division

American Aerophysics Corp. has added a fiberglass division with facilities for development and fabrication of high-strength fiberglass-reinforced laminates for the missiles industry.

The new division will design and produce jet vanes, rocket exhaust nozzles, missile fins and control surfaces, radomes and other equipment.

Callery Chemical Moves Headquarters

Callery Chemical Co. has moved its administrative and sales offices from Callery, Penna., to Pittsburgh. The company recently established new plants at Muskogee, Okla., and Lawrence, Kansas. The Callery, Penna., facilities will remain as R&D division headquarters for the company, which manufactures boron chemical compounds and HEF for missiles.

Laminair Has New Plant

Laminair, Inc., specializing in missile structural and radio frequency fiberglass laminates, has opened its new plant in Gardenia, Calif. The new plant has complete tooling and production facilities for work in polyester, epoxy, phenolic and silicone resins.

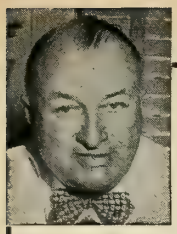
Ryan Declares Dividend

Ryan Aeronautical Co. has declared a regular quarterly dividend of 10 cents. This will be Ryan's 28th consecutive quarterly dividend and the 48th since incorporation.

Temco Sales Up

Temco Aircraft Corp.'s sales for the first half of 1957 were at a record high level, rising 56% over a like period in 1956. Backlog of orders at the company's three plants stands at approximately $172 million.

Circle No. 90 on Subscriber Service Card.



West Coast Industry

By Fred S. Hunter

Lockheed Missile Systems division's new test facility is beginning to take shape near Santa Cruz. Only a few pre-fabricated buildings have been erected, but during the coming year more than $1 million will be spent for site improvement and, if the program is expedited, this figure may go to $2.25 million. First steel test stand is to be ready for rocket firing to begin in February. Four more stands may be erected by the end of 1958 at which time Lockheed expects to have 100 to 150 employes permanently stationed at the Santa Cruz mountain site. Four members of a small-explosive test group comprised the first transfers to the new test center from Newhall recently.

•

Marquardt Aircraft added 300 people to its payroll in one month this summer, highest monthly hiring record since the company's formation. Total is now 3500. Expansion of Marquardt's Van Nuys plant reflects the more realistic view taken by the Air Force toward dispersal. When the late Harold Talbot was secretary and running the show, plans were to move everything to Ogden, including the executive offices. Now research and development stays in Van Nuys with production at Ogden. Marquardt has 450 employes at Ogden where it is now turning out Y ramjet engines for the *Bomarc*.

•

Ryan Aeronautical has completed transfer of all *Firebee* jet drone missile assembly activities to its new Torrance division. Included are final assembly, sub-assembly, electrical shop, painting and engine run-up operations. Fabrication work remains in San Diego. The old *Firebee* final assembly building at the east end of the Ryan Plant at San Diego is now being occupied by Douglas DC-8 pylon main assembly fixtures.

•

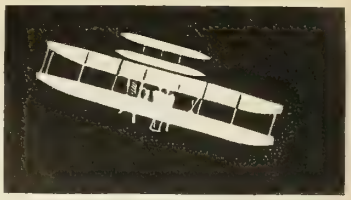
Fred H. Rohr, chairman of Rohr Aircraft Corp., says his company expects to participate in missile programs when production manufacturing gets under way. Rohr has been phenomenally successful in the development of aircraft manufacturing techniques, particularly in the field of power packages, and rates very high with old customers like Boeing, Convair and Lockheed. The Chula Vista company undoubtedly will become an important sub-contractor in missile production when the market is ready.

•

Douglas Aircraft's Elizabeth, N. C. division, which started out to be a second source for the *Nike*, is now the sole source, following the Army's transfer of all production on the ground-to-air missile from Santa Monica. But Santa Monica isn't hurt particularly. It can make use of both facilities and manpower on its nuclear tipped air-to-air MB-I *Genie* program. The potential here is very high. This rocket is reported to be so good you might describe it as being "almost as good as they say it is."

•

Air Force cancellation of the *Navajo* was not as abrupt or unexpected as the Los Angeles press made out, but it was a mistake in view of the fact that it came after around $625 million was spent on the program. For that much money the Air Force should have carried it on a little further, or it should have cancelled it before it spent so much. Most people out this way, of course, think the program should not have been cancelled.



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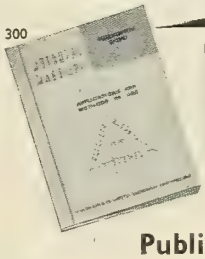
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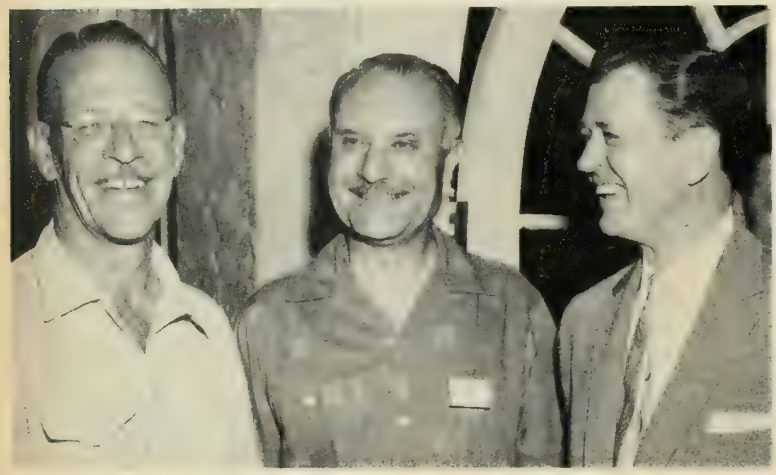
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Beckenham 0041

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Cool as a transistor, JUPITER radio-inertial guidance conferees choose a reliable way to escape 110° Phoenix heat. A young lady whose name for reasons of propriety shall remain anonymous umpires from the shoulder of Mike O'Connor, Motorola's JUPITER contract manager. And swinging around the back arc l. to r. are Lloyd Hershey, Motorola-Phoenix's project manager; Carl Shannon, administrator of Motorola engineers at Jet Propulsion Laboratory; Charles Raudenbush, Motorola-Riverside (Calif.) JUPITER program director; Jerry Landsman, Motorola-Riverside field representative; and Major L. Frankenstein, planning officer, JUPITER project at Army Ballistic Missile Agency, Huntsville, Ala. The three in front are Bob W. Barton, military electronics marketing manager for Motorola; Cliff Cummings, JPL's JUPITER program director; and Daniel H. Murphy, acting legal director for Army's ABMA.



To left, Cal-Tech's rocket pioneer Milliken, AF Deputy Chief of Staff for Development, Lt. Gen. D. L. Putt, and AFOSR chief Brig. Gen. H. F. Gregory at a party at Trade Winds Club Hotel, Melbourne, Fla., during recent meeting of Scientific Advisory Board.

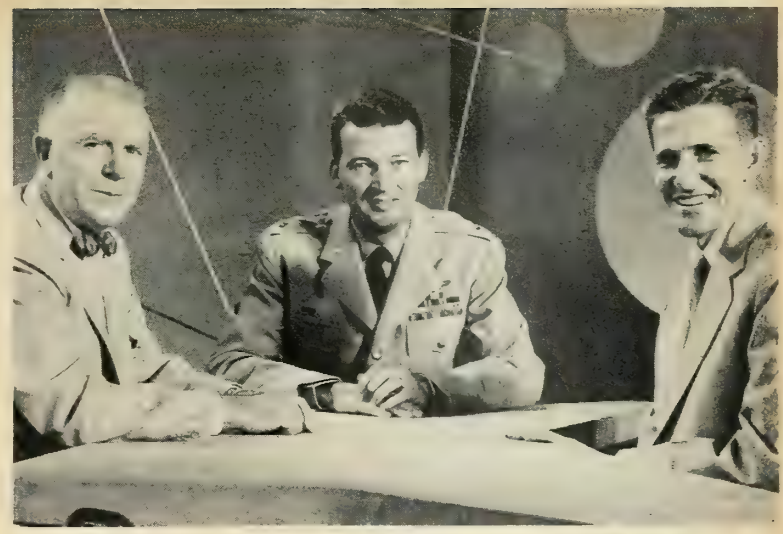


Above, Chrysler Corporation Vice President for Defense and Special Products T. F. Morrow has his problems too, as JUPITER-THOR decision day approaches. Chrysler is prime contractor for REDSTONE & JUPITER.



To the left, Gen. Earle E. Partridge, Commander in Chief, Continental Air Defense Command, and Gen. James E. Doolittle (Ret.), of the Shell Oil Co. at SAB party.

To the right, Dr. Hubertus Strughold (left), Maj. Gen. Bernard A. Schriever and an associate discuss space medicine problems of the future when manned rocket flight is common.



Below, Commander Robert Truax, USN, has had his tour of duty with AF ARDC Ballistic Missile Division extended, which means he will not work on the POLARIS for some time.



To right, Dr. Joseph Kaplan, Professor of Physics, University of California and a member of AF Scientific Advisory Board snapped with missile friends at Trade Winds Club.





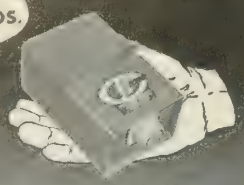
C. A. Brady, Operating Manager of Missile Operations, Chrysler Corporation. At stake in current Army-AF squabble over IRBMs is his company's contract for Army's JUPITER.

General Curtis E. LeMay, Vice Chief of Staff, USAF, Lt. General Thomas S. Power, Commanding, USAF Strategic Air Command, and Maj. General Bernard A. Schriever, Chief of the AF Ballistic Missile Division (standing), at recent Scientific Advisory Board party.



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Units can be equipped with synchronous motor starter and magnetic amplifier, automatic voltage regulator

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KATO MOTOR GENERATOR SETS are available in frequencies, speeds and sizes for every specialized use . . . operating high cycle tools, testing components and electronic equipment.



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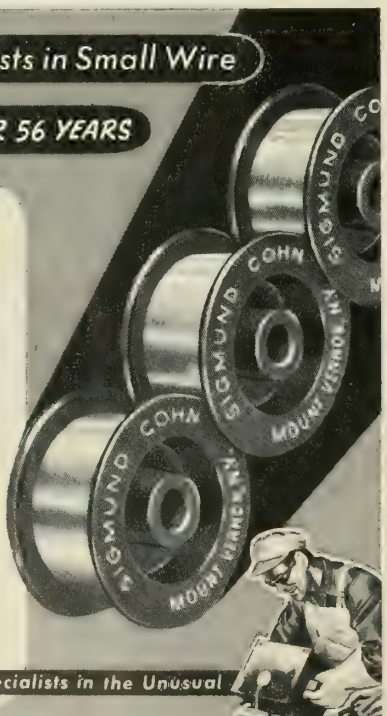
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COATED WIRES . . . Comprising an extensive range of electroplated grid wires . . . Enamel insulated wires for precision resistors and potentiometers.

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people

Anthony Drabicki has been appointed chief application engineer for fluid systems and components for the Waldorf Instrument Co. The company, a division of F. C. Huyck & Sons, also named **John Borah** as southwestern sales manager.

Dr. Martin J. Gould is now director of research at National Electronics Laboratories, a subsidiary of Thiokol Chemical Corp. Dr. Gould recently served as research specialist at the missile test center, Patrick AFB. He will direct guided missile research at NEL with two assistants, **K. W. Hoover** and **H. R. Corbett, Jr.,** both of whom were also at Patrick's missile test center previously.

Willard D. Walker has been appointed chief electronics engineer at Convair-Astronautics.

William H. Shapiro has been appointed manager of engineering services for the rockets division of Bell Aircraft Corp. Shapiro has been with Bell since 1936 and worked on the first jets produced by the company, as well as the X-1 series of rocket-powered planes.

James B. Kendrick has joined the guided missile research division of Ramo-**Wooldridge** Corp. as chief of preliminary design. Kendrick was formerly instructor of aeronautical engineering at MIT.

Stephen J. Jatras has been appointed to the newly-created post of assistant to the director of Lockheed Missile Systems Division's research and development branch at Palo Alto. Jatras will be succeeded as manager of the R & D coordination division by **Russell L. Reiserer,** formerly assistant chief of the fighter design branch, Navy Bureau of Aeronautics.

Frank S. Wyle has formed a national organization of sales and service engineering specialists in missile testing which will represent independent testing laboratories and test equipment manufacturers.

Dr. Sholom Arzt, research physicist who worked on the *Terrier* and *Talos* missiles, has joined Universal Transistor Products Corp.

Brig. Gen. Romulus W. Puryear has been named Chief of Staff for Headquarters, Air Defense Command. He assumes his post after having served as Commander, 25th Air Division at McChord AFB, Washington.

Lt. Col. Carlo R. Tosti has been named director of information services for ARDC succeeding Col. **Albert A. Arnhym,** who is being reassigned to SAC.

John B. Pearson (RADM, USN, Ret.) has been named director of development planning for North American Aviation. He will head a new corporate office responsible for analysis and coordination of planning for future product developments.

U. Victor Turner is newly-appointed general manager of Vitramon, Inc., producers of electronic components, and will direct all plant operations of the company.

Edwin R. Gamson has joined Telemeter Magnetics computer memory producer, as director of manufacturing. He was formerly reliability coordinator for Autonetics Division of North American Aviation.

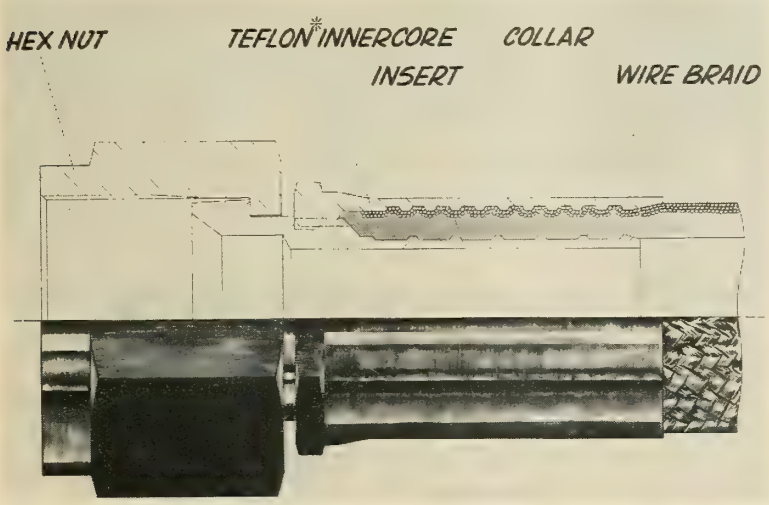
Four appointments to the newly-created Policy Advisory Board of Argonne National Laboratory, the AEC's R & D center, have been made. They are **H. R. Crane,** University of Michigan; **Robert C. Gunness,** vice-president, Standard Oil Company (Indiana); **George A. Hawkins,** Purdue University; and the **Very Rev. Theodore M. Hesburgh,** president of Notre Dame University.

NEW MISSILE PRODUCTS

PERMANENT FITTING FOR FLEXIBLE LINES

A new type of permanent fitting, described as optimum in both design and performance, has been developed by Titeflex, Inc. Flexible lines equipped with the fittings have exceeded MIL-H-25579 (USAF) and are applicable to 1500-psi fluid systems in missiles and rockets.

The amount and direction of flow of both the plastic and wire braid are carefully controlled to obtain the optimum distribution of forces between the hose and the fitting. The seal does not leak



As shown in the figure, the hose is retained between an insert and a collar. Originally a loose fit over the wire braid, the collar diameter is reduced a predetermined amount by radial pressure applied progressively along its length in a rotary hydroforming machine. The plastic innercore and the braid are worked forward toward the hex nut, resulting in a lock between braid and fitting, and between innercore, braid and insert.

in a temperature range from —70°F to 450°F. Titeflex reports that they have never had a fitting blow off a line during their entire test program.

The company has straight fittings, 45° and 90° elbows, and sizes range from 3/16″ nominal hose diameter up to 1¼″ hose diameter.

Circle No. 220 on Subscriber Service Card.

FLIGHT CONTROL ACCELEROMETER

A remote-control electric actuating device has been made an auxiliary feature



in the Genisco model DDL accelerometer now in production. The new configuration is designated the model DDT and embodies a pair of miniaturized solenoids which permit either pre- or in-flight simulation of full-scale operational accelerations by displacement of the sensory mechanisms.

The device is useful when rapid functional tests are required to insure instrument reliability prior to or during flight. Inclusion of the device does not modify the performance of the standard DDL model.

Complete performance and environmental figures are available from the company.

Circle No. 210 on Subscriber Service Card.

ALL-PURPOSE OSCILLOGRAPH

An improved model of the Hathaway S-25 oscillograph has been introduced by



the company, a division of Hamilton Watch Co. The unit, named the S-25C, is a multi-element, all-purpose oscillograph designed for unlimited application, convenience of operation and high-quality recording. The device is cartridge-loaded and uses 12″ wide recording paper capable of recording 18 or 48 channels.

Circle No. 206 on Subscriber Service Card.

ALIGNMENT DEVICE

A device to monitor inertial guidance systems has been developed by Perkins-Elmer Corp. The instrument is designated the Model 169 Auto-Theodolite, and makes it possible to align inertial guidance systems in missiles by detecting angular displacements in the azimuth alignment of the basic monitored equipment.

Functioning of the device is as follows: Two modulated glow lamps in the optical unit of the theodolite direct to the mirror of the monitored system. If the gyro in the guidance system is perfectly squared with the optical axis of the theodolite, the reflected light from the mirror reenters the theodolite objective and is lost back in the light source. If the mirror in the monitored unit is rotated slightly in azimuth, the returning light beams will not be centered on the optical axis and some energy will enter a light-responsive device through a slit. This energy is transduced to an electrical signal which indicates an error in alignment. A corrective signal can then be applied manually or automatically to the drive elements of the monitored system.

The Auto-Theodolite consists of three major components—an optical unit, mount unit and electronic unit. Two distinct and independent systems comprise the optical unit—a supporting base with levelling means and a precision optical limb and reading system for setting off the desired angle between the two optical axes. The theodolite has the electronic control box mounted directly on it to form a compact and readily accessible unit.

Circle No. 228 on Subscriber Service Card.

VARIABLE TIMER

Universal Winding Co. has developed a variable timer for use in missile sys-



tems, programming devices and explosive element initiation. The unit provides for a settable time delay between 0.3 and 10 seconds, with an accuracy of ±5%, and output energy in excess of 35,000 ergs. Temperature ambients from —70°F to 165°F and accelerations up to 100 g's have no effect on the device, which is termed the PM-47.

Transient circuits are used to achieve the delay, which is furnished by components of the weapon approved non-

power-consuming type, i.e., no tube filament power, etc., is required. The selected time delay is obtained by applying between 100 and 400 volts to the device, depending on the delay desired. The delay is initiated by release of a pull wire which allows a spring driven plunger to complete the necessary switching action. At the close of the delay period a pulse of electrical energy is applied to the load.

Circle No. 201 on Subscriber Service Card.

PRECISION STEEL TUBING

Recent order of stainless steel tubing by Carpenter Steel Co. for AEC met tolerances of +.000" —.025" and similar tolerances are available from the company. The tubing is available for missile & rocket applications. It may be covered with insulating material if necessary. Operating temperature on AEC order is said to be 2000°F.

Circle No. 221 on Subscriber Service Card.



Portable test chamber as shown (Size 65" x 54½" x 65") and designed for a low-frequency cut-off at 250 cps. Chamber is mounted on Korfund spring vibro-isolators.

DESIGNED FOR SOUND TESTING SMALL ELECTRONIC AND MECHANICAL DEVICES

AN-ECK-OIC® Chambers are used for:

* determining acoustical characteristics of radio, TV, audio equipment;
* analysis of noise in mechanical and electrical equipment such as air conditioners, refrigerators, household appliances, office machinery, motors, transformers;
* free field calibrations of microphones, loudspeakers, hearing aids, etc.;
* psycho-acoustic studies;
* sound power level measurements and other applications.

Low-frequency cut-off in portable chambers down to 150 cps.

Low-frequency cut-offs in built-in chambers down to 50 cps.

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AN-ECK-OIC® Wedges ECKOUSTIC® Panels

Circle No. 93 on Subscriber Service Card.

SECONDARY PRESSURE STANDARD

A pressure standard for calibration of pressure instruments and for making



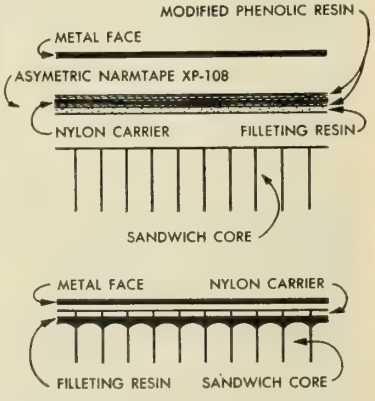
direct pressure measurements is being introduced by Wianco Engineering Co. The portable, compact unit has an overall accuracy of ±0.05% of full-scale ranges of 5 psi to 2500 psi, and ±0.1% for ranges of 3000 psi to 10,000 psi.

The unit weighs 25 lbs., has interchangable pressure heads, and only one secondary standard is necessary for any number of pressure heads. The unit's output may be displayed on a frequency counter or recorded in digital form on standard digital printers. The device is adaptable to measure other parameters, such as force, acceleration and displacement.

Circle No. 204 on Subscriber Service Card.

STRUCTURAL ADHESIVE

An adhesive designed to eliminate the need for core priming in missile sand-



wich component fabrication and also to provide materially improved peel strength, has been developed by Narmco Resins and Coatings Co. Tradenamed "Narmtape XP-108," the new adhesive is said to be the first asymmetric structural adhesive available to the missile industry, and consists of a nylon carrier impregnated with a modified phenolic resin. It is overcoated on one surface with a highly mobile filleting resin.

The addition of this filleting resin, according to Narmco, will eliminate the priming step of bonded sandwich construction operations. The new adhesive is resistent to fuels, salt spray, solvents and corrosive materials.

Circle No. 202 on Subscriber Service Card.

CIRCUIT TESTER

A device capable of testing 1200 electrical circuits in a minute has been introduced by Republic Aviation Corp. The automatic circuit analyzer is simple to operate and can be used on any multiple-circuit assembly. Removable program boards that mate with a receiver mechanism can be employed to reduce costs. The analyzer not only detects reversed, shorted or open circuits, but also determines immediately all those circuits involved.

Five models of the checker have been designed with capacities of 200, 400, 800, and 1200 circuits, in addition to a 100 circuit light-weight portable model for field use. The units can be built to operate from any power source and no modification is necessary to test different types of circuit harnesses, the changeover between types achieved with plug-in, pre-assembled adapters. An automatic megger to detect current leakage through wiring insulation is optional. Other special requirements can be built to customer specifications.

Circle No. 229 on Subscriber Service Card.

AUTOMATIC MOTOR TESTER

Servo-motors of 1/50 to 1 hp capacity, as well as other motor types, may be



tested in a new test stand developed by Magtrol, Inc. The test stands are designed to completely test a motor in three or more dynamic phases of torque, speed and current characteristics and feature four-digit electronic tachometers to indicate motor speed.

Seven basic dynamometer heads are available, covering the range from 1 oz. in. to 750 oz. in. torque capacity, and capable of checking motors in three phases: no-load check of speed and current; dynamic check of speed, torque and current; second dynamic check of speed, load and current at any point on the curve, of stall current and stall torque check.

The control sequence may be initiated manually by a single start button for each phase, or it may be sequenced automatically.

Circle No. 200 on Subscriber Service Card.



NEW LOW-NOISE CHOPPER

Bristol's Syncroverter† chopper is now available in a low-noise, external-coil model for critical dry circuit applications.

This new external-coil chopper virtually eliminates capacitive coupling between signal-circuit contacts and driving coil leads. Peak-to-peak noise levels are usually *less than 100 microvolts* across a 1 megohm impedance (rms noise, in the order of 10 microvolts).

LONG LIFE and immunity to severe shock and vibration are outstanding characteristics of the new Syncroverter chopper. Withstands vibration, 5 to 2000 cps, up to 30G, and up to five 30G impacts on any major axis. SPDT switch action. Nominal contact ratings: up to 10 V, 1 ma.

Write for complete data on this latest addition to the Bristol Syncroverter line. The Bristol Company, 173 Bristol Road, Waterbury 20, Conn. 7.31

†T. M. Reg. U. S. Pat. Off.

TYPICAL CHARACTERISTICS

Driving Frequency Range:	0—1800 cps
Coil Voltage:	6.3 V sine, square, pulse wave
***Coil Current:**	70 milliamperes
Coil Resistance:	52 ohms
***Phase Lag:**	60° ± 10°
***Dissymmetry:**	15° max.
***Switching Time:**	15° ± 5°
Temperature Ranges:	—55°C to 100°C or —65°C to 125°C
Operating Position:	Any
Mounting:	Flange; 2-hole or 4-hole Plug-in; fits 7-pin miniature socket

*These characteristics based on sine-wave excitation, 400 cps.

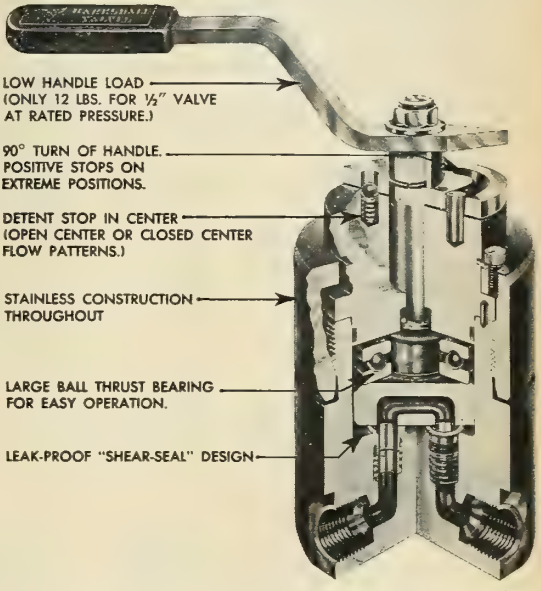
BRISTOL FINE PRECISION INSTRUMENTS FOR OVER 68 YEARS

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10,000 P.S.I.

4 WAY VALVE

FOR LIQUIDS OR GASES



This new four-way valve series comes in pipe sizes from ¼ to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

No port to port leakage occurs in the detented positions because of the exclusive "Shear-Seal" design.

Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.

This highly successful principle of extreme pressure control is fully described in "Shear-Seal" bulletin BVM-2.

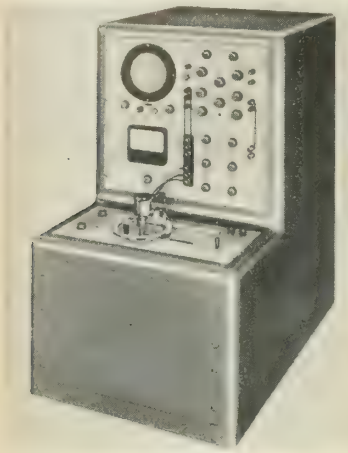
BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

Circle No. 105 on Subscriber Service Card.

LINEARITY TESTER

Linear accuracy in precision potentiometers may be tested with the model TP-800 tester of Technical Products Co.



Use of a long persistent oscilloscope provides display of error signal, and noise due to contact resistance over frequency range of 0 to 100,000 cycles. Individual wire commutation may be shown. Magnetic clamping allows rapid set-up and alignment of test potentiometers.

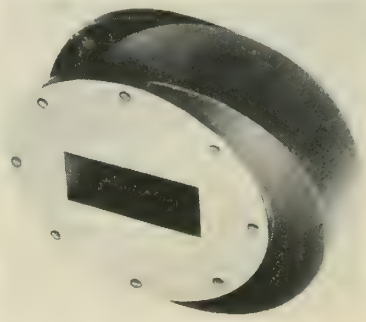
The unit's oscilloscope reads linearity error directly in per cent, in five ranges from .05 to 1.0 per cent of full scale, with accuracies of 0.01%. Terminals provided for recorder operation. A motor-driven precision gear box couples a 40-turn master helipot of .007% linearity to the test potentiometer.

Units of 1, 3, 10, 15, 25, and 40 turns can be accommodated. Test voltages may be selected between 22.5 and 135 volts to give maximum sensitivity for each unit being tested.

Circle No. 222 on Subscriber Service Card.

FERRITE MINIATURE ISOLATOR

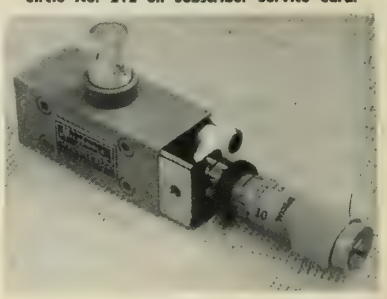
Airtron, Inc. is offering a "C" band 150 kw ferrite miniature isolator designed to operate in the 5000 mc frequency range.



The resonant absorption isolators furnish constant uni-directional magnetron to load isolation and feature a waveguide size of 2.00 x 1.00 O.D. with a weight of less than 3.5 lbs. Electrical characteristics guarantee an isolation of 10 db minimum, insertion loss of 0.5 db maximum, input VSWR 1.10 maximum with matched load and power handling capabilities of 150 kw peak power with 100 watts average into a 2 to 1 mismatch.

Ferrite material is mounted directly on the waveguide wall and full waveguide opening has been used. Heat conduction away from the waveguide is said to be rapid enough to allow operation without forced air cooling. Five units are available to collectively cover the frequency range 5250 to 5750 mc/s.

Circle No. 212 on Subscriber Service Card.



TUNABLE THERMISTOR MOUNT

A Ka-band tunable thermistor mount, with thermistor, designed for sensitive measurement of RF power in RG-96/U waveguide transmission systems is available from Microwave Associates, Inc. Frequency coverage of the unit is 34.0—36.0 kmc/s with maximum VSWR of 1.5.

The unit may be used over the complete waveguide range if higher input VSWR's are not a consideration. Nominal operating resistance is 200 ohms and power handling capacity is 10 milliwatts maximum. Insertion loss is determined at 34.86 kmc/s and the value marked permanently on each unit and the accuracy of the measurement is ± ¼ db.

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DATA PROCESSING SPECIALISTS!

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Engineering services is a member of an integrated five-company missile systems corporation which designs and manufactures its own data-processing equipment. Our efforts are directed toward the "systems concept." We are engaged in the reduction of large amounts of flight test data being generated by the daily missile firings on the integrated Holloman-White Sands range.

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*LOX GRADE KEL-F**

Unsurpassed resiliency at—320°F is offered in our especially processed Kel-F* for rocket and missile seals. Sheets and tubes to 18 inch diameter are available, exhibiting unusual clarity and a minimum of cold flow throughout the ambient range.

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Circle No. 106 on Subscriber Service Card.

VALVE WARMER

A valve warmer incorporating low cost features as well as light weight, easy installation and space saving has been introduced by Dean Products, Inc.



The device is made of two sheets of metal, with the outside sheet embosed to create flow channels. The inside sheet, which is flat, provides greater heat-transmitting contact. The two sheets are welded together and curved to fit the valve.

The unit is said to be easy to install or remove for valve inspection.

Circle No. 227 on Subscriber Service Card.

THERMAL SWITCH

A hermetically-sealed two-wire thermal switch designed for use in bearings, pipes, etc., and using a bimetal element



n a stainless steel body has been introduced by Control Products, Inc. The switch operates in ambient temperatures from —65°F to 700°F, has an electric rating of 2 amps and is resistive at either 28V dc or 115V ac. Length over AN connector is 5/16" and it is designed to meet environmental, shock and vibration requirements of MIL-E-5272A.

Circle No. 215 on Subscriber Service Card.

THREE-WAY VALVE

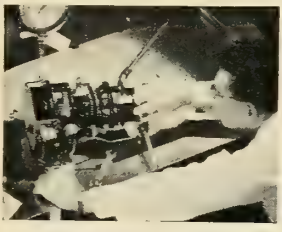
Designed for highly corrosive materials, this valve features flow through any two selected ports, while automatically shutting off the third port. Valve operation employs a self-wiping and self-lapping action which is free of wear-producing shocks and needs no lubricants



TEST EQUIPMENT

The Test Equipment Engineer is engaged primarily in the design of specialized missile check-out equipment. As missiles push the state of the art, test equipment must exceed the missiles in precision and reliability. Automatic programing, go-no-go evaluation, and automatic data processing add up to automation in missile testing.

This engineer is evaluating his design of a precision power supply—one of the building blocks that will be system engineered into a family of versatile matched missile and sub-system test equipment. Engineers work as individuals.



HYDRAULIC DESIGN

Excellent opportunities are available for the engineer to observe the performance of his design. Here, under the watchful eyes of its designer, a hydraulic power unit is undergoing adjustment and setting prior to severe testing at simulated high altitude conditions.

Many components, which a few months ago seemed almost impossible to design, are now being tested under the severe conditions required to qualify them for flight operation—and passing with flying colors.



STEERING INTELLIGENCE

Two Steering Intelligence Engineers discuss space allotment in a new guidance component. This close association of engineers with the "flying" equipment is typical of the Steering Intelligence Section. Engineers in this section are primarily *and directly* concerned with refining the guidance equipment to steer the missile with greater accuracy, at greater ranges and with simpler and more reliable electronic equipment and, consistently, with minimizing the cost. Work is actively in progress in every principal field from microwave equipment to inertial end instruments.

Bendix

PRIME CONTRACTOR FOR TALOS MISSILE



Offers more interesting and challenging job opportunities!

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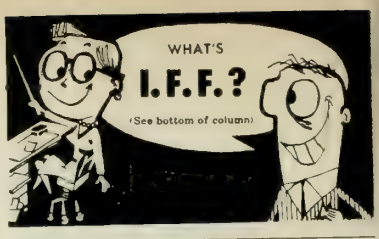
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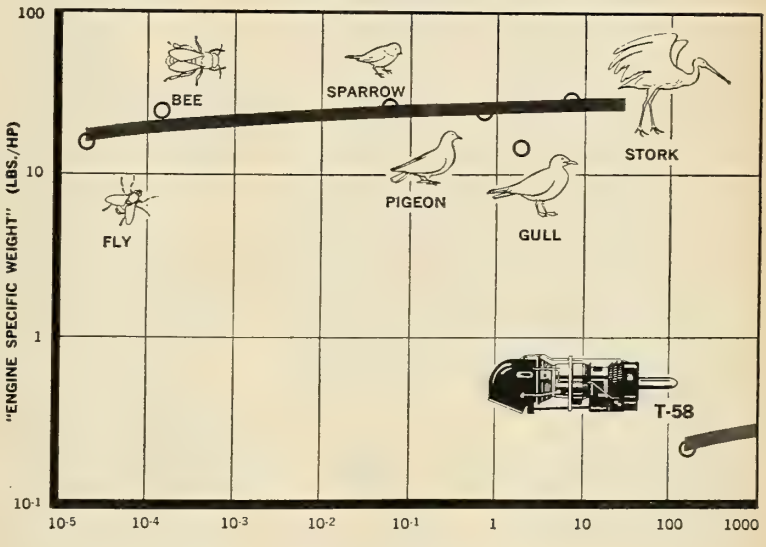
FROM STOKE'S LAW for the very small to Hoyle's work with the very large, the "3/2 power" principle maintains its validity. For an example in the middle range of our immediate experience, note the curves on the chart (1).

The variation of propulsive thrust with the square, and of "engine" weight with the cube of linear dimensions results in the well-known fact that propulsive efficiency increases with decreasing power plant size...whether one studies insects, birds, or aircraft gas turbines.

For the engineer who is curious about the application of engineering principles in nature, we recommend D'Arcy Thompson's "Growth and Form".

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NOTES AND REFERENCES

1. Values for the "engine specific weight" of the insects and birds were derived from Thompson . . . cf. "Growth and Form," 2nd Ed., 1942, Cambridge University Press; Chapter II on magnitude, especially pp. 45, 47. Birds were assumed to fly at 30 mph, insects at 5 mph.

2. The T58 Turboshaft — 250 lbs. without reduction gear, 1050 HP — now in production. The T64 Convertible — for turboprop or turboshaft use, depending upon gearing — now in development; the J85 Turbojet — details still classified.

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HALOFLUOROCARBON POLYMERS. A technical booklet on "Kel-F" brand halofluorocarbon polymers, discussing their properties and possible applications, has been published by the Minnesota Mining and Manufacturing Co.
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HYDRAULIC PUMPS. Bulletin A-5216 Vickers Inc. describes miniaturized hydraulic components for missile use. Pumps also alterable to function as hydraulic motors. Vickers Inc.
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FILTERS. Micro-magnetic filters designed to operate at pressures to 3500 psi are described in a folder published by Cuno Engineering Corp.
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ELECTRONIC FLUOROSCOPY. Modern techniques for applying electronic fluoroscopy in metal examinations are described in a six-page folder available from Philips Electronics, Inc. Instrument Division.
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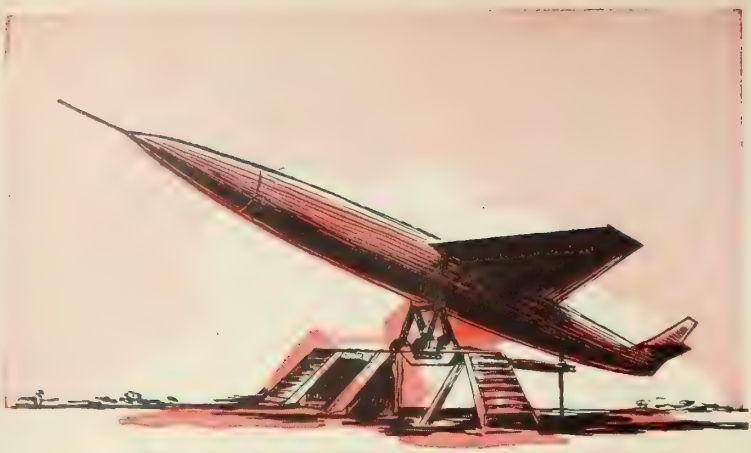
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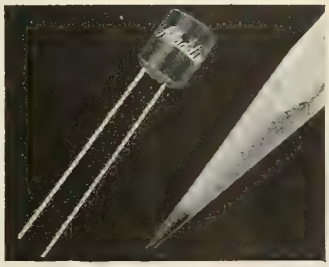
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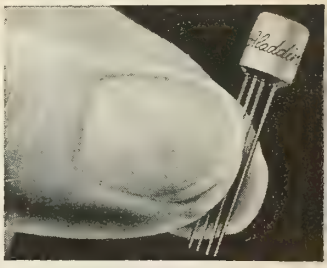
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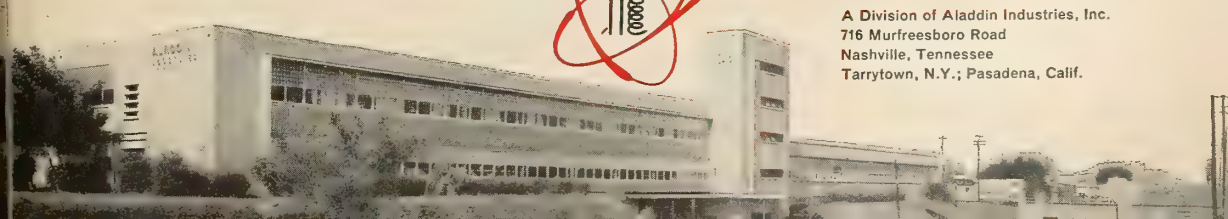
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189 standard catalog units, ideal for transistor circuit applications.

Write for the complete encyclopedia (Bulletin 55).

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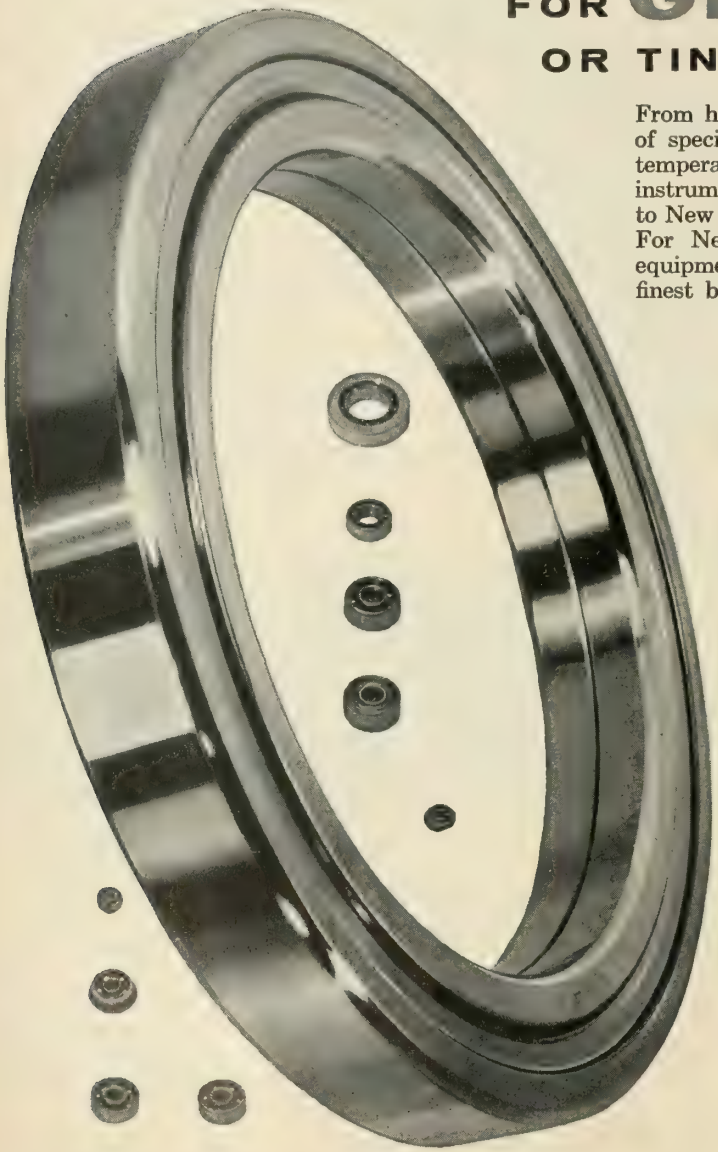
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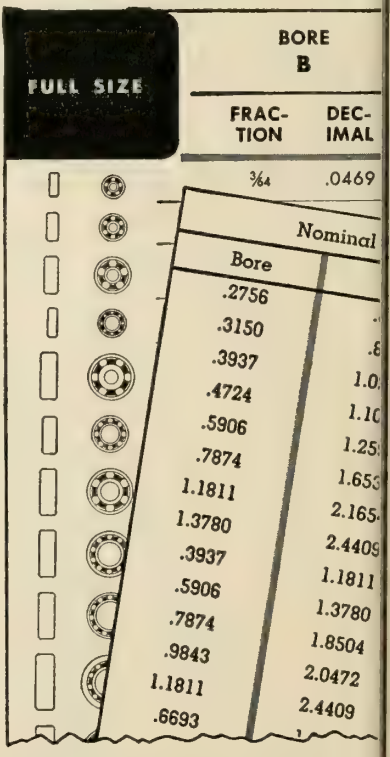


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Oerlikon's type 54 SAM, over 19 feet long, is regarded as one of the world's best antiaircraft missiles. The type 54 is a beam-rider and utilizes a liquid propellant engine burning white fuming nitric acid and kerosene. The beam-transmitter of the type 54 system is shown on the cover of missile electronics *(following page 156) and has both coarse-beam and fine-beam guidance.*

columns

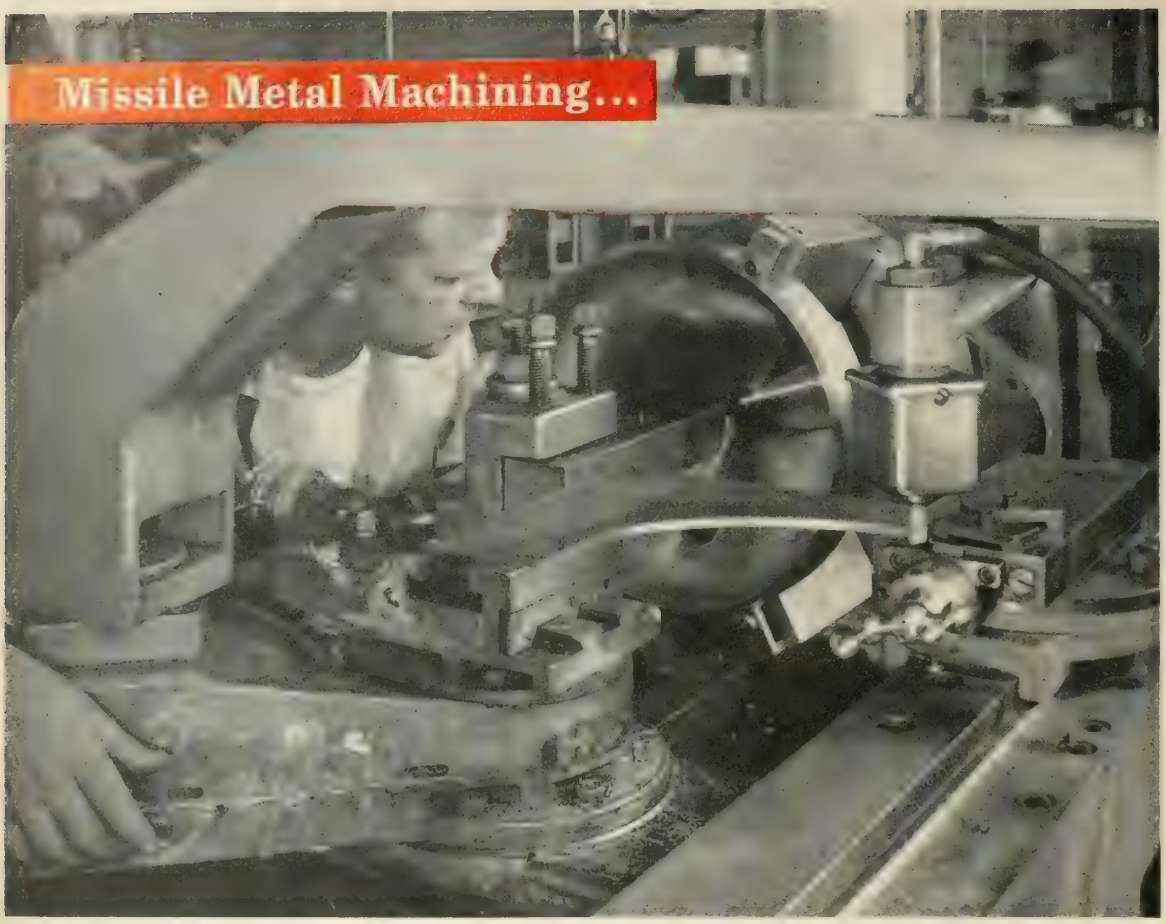
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FROM BLANKS TO BULKHEADS!

The Diversey craftsmen above is machining the inner diameter of a Forward Bulkhead of the Hawk missile to a fine 63 microinch finish. Notice the precision curved template in the center of the picture with the follower at the right end transferring the contour to the interior of the bulkhead. Another good example of the famous air gage tracer lathe technique that has brought the missile hardware field to such an advanced state.

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From Air Force to Space Force

Washington defense planners and Air Force officials were jolted recently by a brilliantly written article in LOOK magazine. With the cover headline "The Coming Death of the Flying Air Force," LOOK introduced to the man in the street one of today's most thought-provoking topics. This inevitable article expressed the views that Air Force people themselves have been too frightened to mention in the open. This is in spite of the fact that AF experts such as General Nathan Twining have warned that the AF must encounter considerable cuts in terms of manned planes and that missiles are on the way in.

The LOOK article meticulously detailed the increased use of missiles in place of aircraft—a view that we have shared and expressed in our columns since our very first issue. Nevertheless, the LOOK article built chronologically to the "coming death of the flying Air Force," implying that with the ascendancy of the missile in current military concept there would be no need for a separate air force.

We disagree with this view. You don't need to be an expert to foresee that the Air Force will continue to be our most important arm of retaliation for immediate action against any Russian blow against the Free World. But the Air Force gradually will become a Space Force—with clipped wings, with rocket ships instead of airplanes. By-and-by our Air Force will have to build up a space force system. Today's fighter squadrons will become space reconnaissance squadrons tomorrow. Goodbye to the pilot? No, tomorrow's rocketcraft will be manned. They will be manned by a new breed of pilot. Col. John P. Stapp, Maj. David Simons and a few others are paving the way for these pilots of tomorrow. And our space force will pave the way for the new defense system in general.

The question remains, however, whether our Air Force planners fully comprehend all this. Do they have the vision to understand that now is the time for transition from planes to missiles and spacecraft?

The Air Force will never become a Space Force by capriciously cutting Air Force Office of Scientific Research's expenditure rate. It will never become a Space Force if it continues to allow routine personnel action to put out to pasture such pioneering scientific genius as that of Col. William O. Davis, Deputy Commander, Operations, AFOSR.

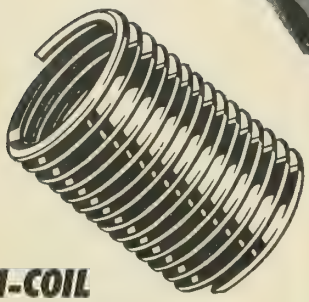
AFOSR has one of the smallest budgets in the country. Yet, for the future of America's military security, for man's advance into space, there is no office or agency that is more important. Nor in the experience of this country's rocket men is any one more capable of aiding and abetting this advance than Col. Davis. The murmur of protest at the AFOSR budget cut has swelled into a rumble, and top Pentagon planners had second thoughts. The money has been reinstated. There are no such reports however that minds will also be changed about Bill Davis' impending transfer to conventional duties in Dayton.

The fact that AF would cut its exploratory research budget and shuffle off one of its most practical and imaginative researchers is bad enough in itself. What is more fundamental, however, is the existence of thinking in high places that would permit such actions to occur. It is the thinking of men chained by links with the past and blinded by the brilliance of the future, of men who think tomorrow will be just like today. It is the kind of thinking that will, in fact, make the LOOK article a forecast of things to come; that will in fact assure the "Coming Death of the Flying Air Force."

ERIK BERGAUST

Here's Use

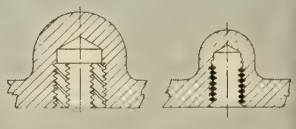




HELI-COIL Stainless Steel Screw-THREAD Insert

This is the insert that permanently protects threads against wear, stripping, corrosion, galling, seizing, vibration and shock. Made of (18-8) stainless steel wire, cold-rolled into a diamond shaped cross-section, this ***Heli-Coil*** Insert is work hardened to a tensile strength of approximately 200,000 psi . . . conforms to military standards MS 122076 through 122275 (ASG) and MS 124651 through 124850 (ASG) . . . conforms to standard commercial and industrial thread forms, including coarse, fine, pipe-thread and MM sizes . . . permits use of standard boss configurations.

Here Are



Save Space, Weight and Costs

Substantial savings in materials, weight, space and costs are possible, as against solid bushings, because smaller (or standard) bosses, flanges and threaded fasteners can be used.



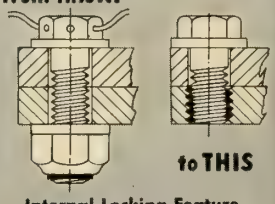
New HELI-COIL Stainless Steel Screw-LOCK Insert

Pat. Pending.

Conforming to military specifications for locking torque and vibration, this notable new ***Heli-Coil*** Screw-LOCK *one-piece* insert provides all the thread protection of the Screw-THREAD Insert, **PLUS** an exclusive internal locking feature that eliminates the need for clumsy protruding lock nuts, lock wiring and other supplementary locking devices . . . saves cost, space and weight . . . permits simplified streamlined design. The Insert is a permanently integrated part of the component—permits repeated service repair disassembly and reassembly, *with locking action remaining unimpaired.* Available in sizes from 4-40 up.

Here Are

from this...



to THIS

Internal Locking Feature

Insures positive internal locking action—eliminates lock nuts, lock wiring and other protruding locking devices—saves space, weight, cost. Yet screw may be easily disassembled with no loss of locking torque.

➡ ***Heli-Coil*** **Field Engineers are at your service for**



CUSTOM LOCK NUTS

The ***Heli-Coil*** Screw-LOCK Insert is adaptable to special-shaped lock nuts, shells, spacers and fasteners and can be engineered to meet your torque or performance requirements. ***Heli-Coil Corporation*** is fully equipped to manufacture these special lock nuts to your specifications.

Note: Custom nuts, with Screw-LOCK Inserts, meet military specifications for lock nuts.

How Design Engineers HELI-COIL* INSERTS to

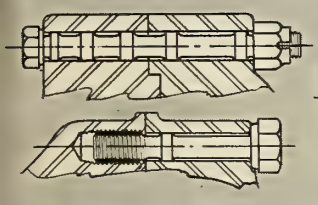
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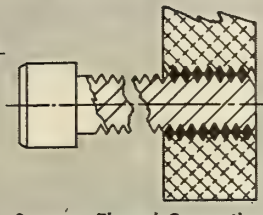
Eliminate Lock Nuts — Lock Wiring — Lock Washers

Some Typical *Heli-Coil* Screw-THREAD Applications



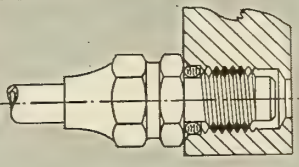
Compact Design

Improves design features by elimination of nuts, washers and extra-length bolts.



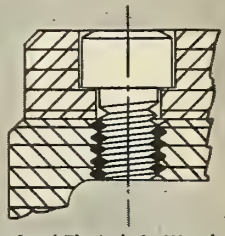
Stronger Thread Connections

Under excessive tension, torsion and impact loads in standard proportion bosses, the screw will break but the *Heli-Coil* Screw-THREAD Insert will remain undamaged . . . even in light alloy metal.



Leak-Proof Connections

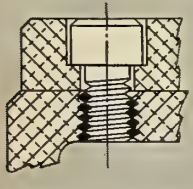
In lightweight, high pressure hydraulic equipment, stainless steel inserts, regular and pipe thread, protect threaded pump and valve ports sealed with "O" rings.



Steel Threads in Wood, Plastics and Fiberglas

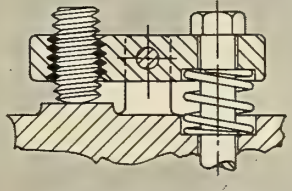
Provides permanent, strong, corrosion-resistant and wearproof threads in soft materials. Especially valuable where frequent assembly and disassembly is necessary.

Some Typical *Heli-Coil* Screw-LOCK Applications



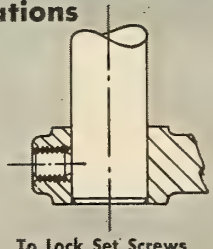
Flush Nut Assemblies

Permits a securely locked, flush assembly, because its internal locking feature eliminates need for drilled head bolts and other protruding locking devices.



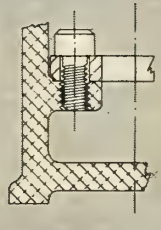
Lock Adjustment Screws

This simple design allows permanent, positive adjustment of screws in any position, secure against vibration or impact.



To Lock Set Screws

Positively locks assembly against loosening at desired adjustment — protects threads against stripping under high torque—permits use of light housing materials.



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design consultation — without obligation.

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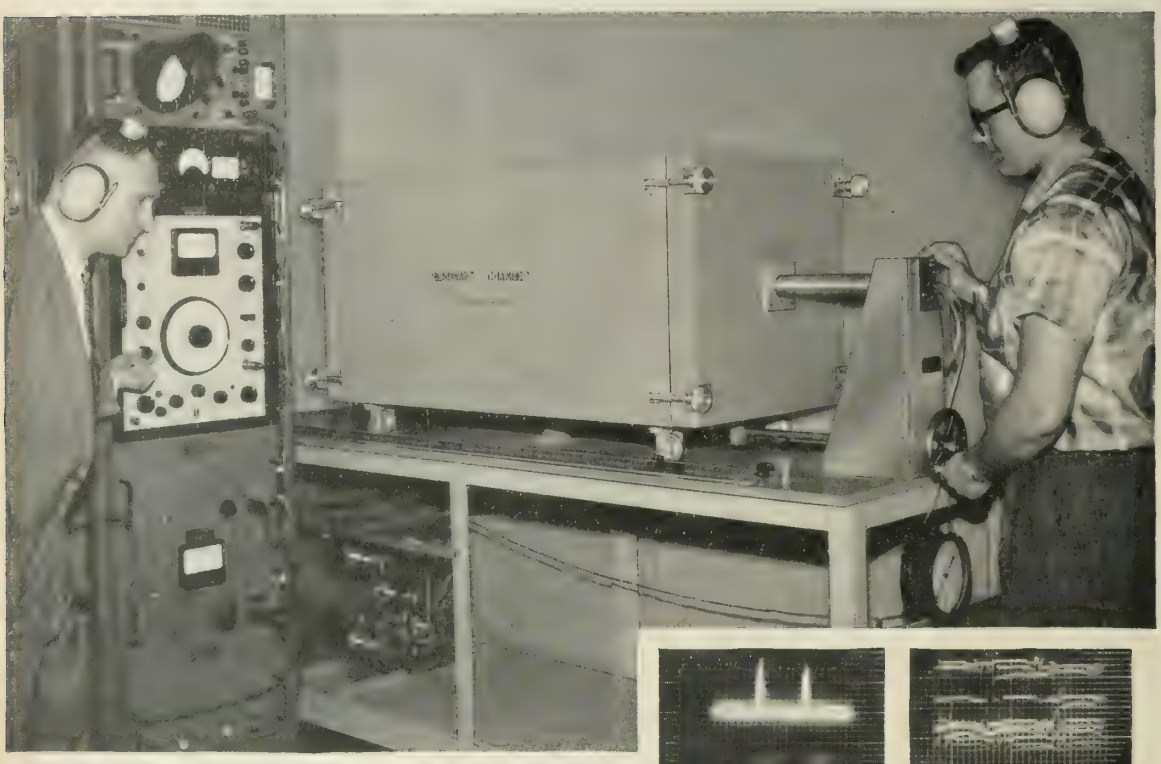
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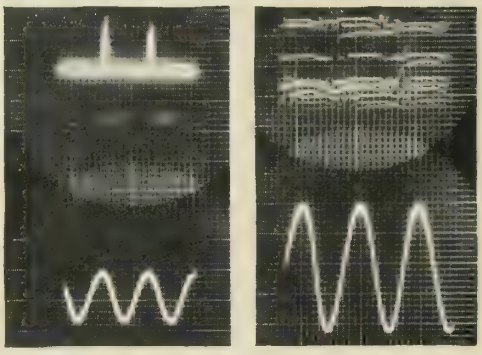
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Bartlesville, Oklahoma

Phillips 66

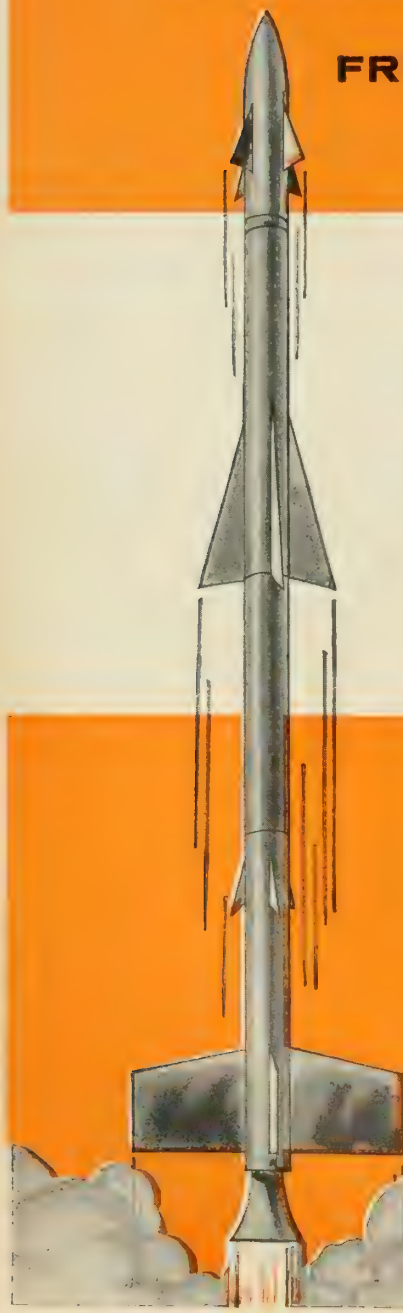
PHILLIPS PETROLEUM COMPANY
Bartlesville, Oklahoma

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Tolerances as close as ± 0.003″ can be achieved in the high-precision forgings produced at the Jet Division. These precise forgings can be made from titanium, stainless steel or high-strength alloys. For many applications, finish machining is eliminated, saving high labor costs and expensive scrap.

Make the Jet Division a part of your missile production program. By letting us produce forged and machined parts and weldments, you avoid the capital expense of your own facilities, eliminate the headaches of recruiting trained personnel, get your missile program under way faster.

Our engineering and test facilities are also available to augment your missile plant. We can handle the complete job of producing missile air-frames, internal structures, and operating components.

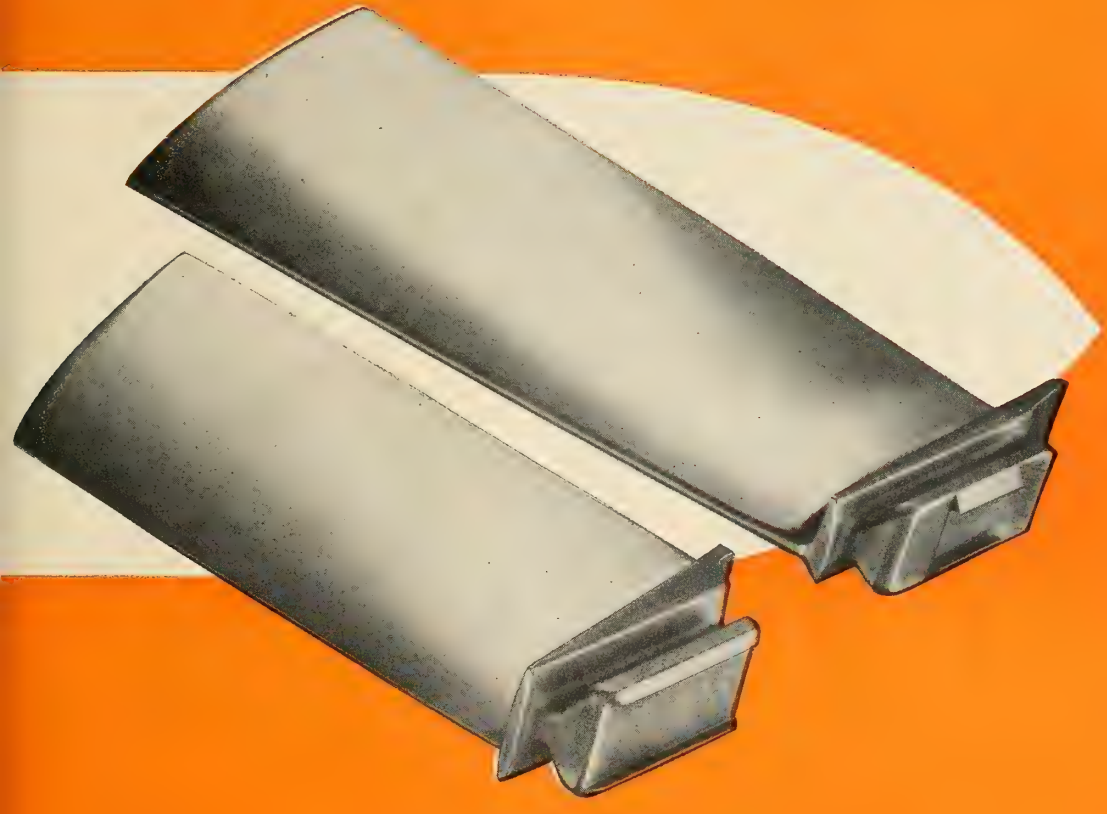
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which describes the engineering and production facilities of the Jet Division. A sales engineer will call at your convenience to discuss our abilities.



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and High-Alloy Forgings

OF JET ENGINE PARTS

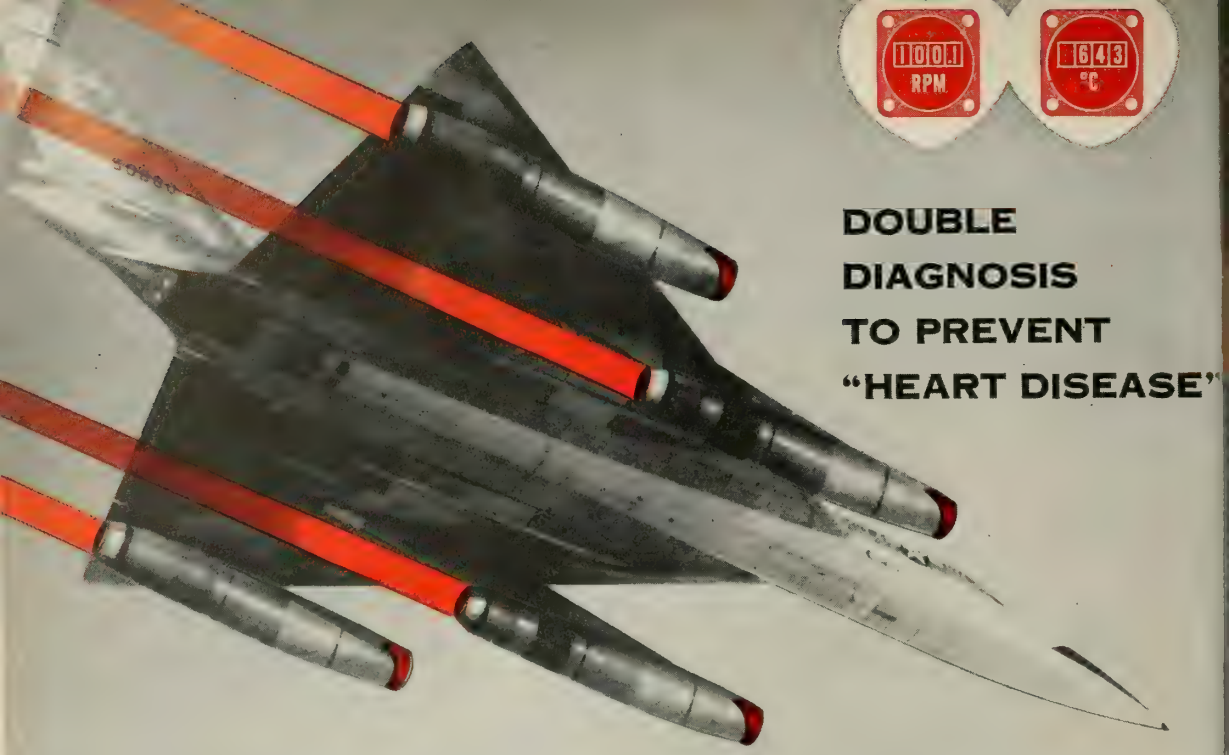


JET DIVISION

Thompson Products, Inc.

CLEVELAND 17, OHIO

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DOUBLE DIAGNOSIS TO PREVENT "HEART DISEASE"

...BY THE B&H JETCAL® ANALYZER

Two of the most important factors that affect jet engine life, efficiency, and safe operation are *Exhaust Gas Temperature (EGT)* and *Engine Speed (RPM)*. Excess heat will reduce "bucket" life as much as 50%, and low EGT materially reduces efficiency and thrust. Any of such conditions will make operation of the aircraft both costly and dangerous. The *JETCAL Analyzer* predetermines accuracy of the EGT and (interrelatedly) Tachometer systems and isolates errors if they exist.

The JETCAL ANALYZES JET ENGINES 10 WAYS:

1) The JETCAL Analyzer *functionally* tests EGT thermocouple circuit of a jet aircraft or pilotless aircraft missile for error *without running the engine or disconnecting any wiring*. GUARANTEED ACCURACY is ±4°C. at engine test temperature.

2) Checks individual thermocouples "on the bench" before placement in parallel harness.

3) Checks thermocouples within the harness for continuity.

4) Checks thermocouples *and* paralleling harness for accuracy.

5) Checks resistance of the Exhaust Gas Temperature system.

6) Checks insulation of the EGT circuit for shorts to ground and for shorts between leads.

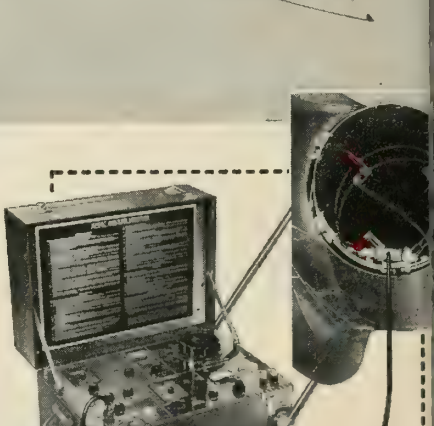
7) Checks EGT Indicators (in or out of the aircraft).

8) Checks EGT system with engine removed from aircraft (in production line or overhaul shop).

9) Reads jet engine speed while the engine is running with a guaranteed accuracy of ±0.1% in the range of 0-110% RPM. Additionally, the TAKCAL circuit can be used to trouble shoot and isolate errors in the aircraft tachometer system.

10) JETCAL Analyzer enables engine adjustment to proper relationship between engine temperature and engine RPM for maximum thrust and efficiency during engine run (Tabbing or Micing).

ALSO *functionally* checks aircraft Over-Heat Detectors and Wing Anti-Ice Systems (thermal switch and continuous wire) by using TEMPCAL Probes.. Rapid heat rise . . . 3 minutes to 800°F! Fast cycling time of thermal switches . . . 4 to 5 complete cycles per minute for bench checking in production.



Tests EGT System Accuracy to ±4°C at Test Temperature

(functionally, without running the engine)

Tests RPM Accuracy to 10 RPM in 10,000 RPM (±0.1%)

The JETCAL is in worldwide use . . . by the U. S. Navy and Air Force as well as by major aircraft and engine manufacturers. Write, wire or phone for complete information.

B & H INSTRUMENT CO., INC.

3479 West Vickery Blvd. • Fort Worth 7, Texas

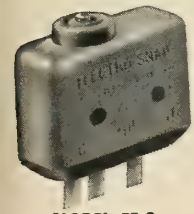
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FOUR PROVEN ANSWERS TO SWITCHING PROBLEMS

Subminiature sealed switch is environment-free; mounts interchangeably with MS25085

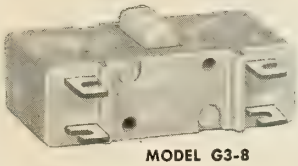


MODEL EF-3

gle Pole, Double Throw
re. Differential, .004 Max.
rtravel, .003 Min.
er. Force, 5 to 17 oz.
ease Force, 60 gram
. Life Ratings:
50,000 ops. @ 125/250 V. A.C., 2.5 AMP.
00,000 ops. @ 125/250 V. A.C., 5.0 AMP.
50,000 ops. @ 30 V. D.C., (2.5 AMP., IND.; 4.0 AMP., RES.)
b. Temp., —65° to +180° F.

Sealed in a corrosion-resistant, treated aluminum enclosure, this tiny switch is environment-free; highly vibration and shock resistant. It carries 5 amps. at 125/250 V.A.C. with an electrical life rating of 100,000 operations. Low operating force and small movement differential make it ideal for bi-metal temperature, diaphragm operated and other "feather-touch" devices, while small size permits mounting singly or ganged in restricted space. Rugged and dependable, it has positive snap action.

ny 40 amp. basic switch has high pacity, longer life and constant ability of tolerances



MODEL G3-8

asuring only 1¾" x 43/64" 5/64", the Electro-Snap G3-8 ic Switch handles current rat- up to 40 amps. A new hod of combining Electro- p's double-break action with eavy-duty switching element ires electrical and mechanical of 100,000 cycles at large acities; also provides constant stability of tolerances and accurate eatability. New plastic compound case gives the switch an am- nt temperature rating of —100° to +300° F. with extreme shock stance. Small size makes it ideal for motor controls and compact omation set-ups. A wide range of actuators is available.

OPERATING CHARACTERISTICS

Single Pole, Double Throw
40 AMPS @ 125/250 V. A.C.
@ 30 V. D.C. Res.
Oper. Force, 45 oz. Approx.
Overtravel, .015" Min.
Move. Differ., .055 ± .010

ELECTRO SNAP

PRECISION SWITCHES



BASIC SWITCHES



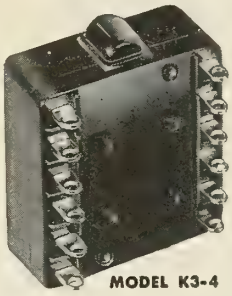
DIECAST ENCLOSED SWITCHES



HERMETICALLY SEALED LIMIT SWITCHES

CONFORM TO MIL & AN SPECIFICATIONS

Simultaneous triple-pole switch interrupts 3-phase ac. circuits; 6-circuit control in a small package



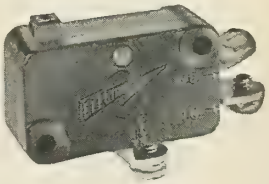
MODEL K3-4

Triple-Pole, Double Throw
15 AMP., 125/250 V. A.C.
30 V., D.C. Res.
10 AMP., 30 V., D.C., Ind.
Overtravel, .015 Min.
Move. Diff., .028 ± .007
Mech. Life, 1,000,000 ops.
Elec. Life, 500,000 ops.

This Electro-Snap triple-pole switch simultaneously reverses current flow through three windings of a 3-phase motor up to 1 H.P. and interrupts other types of multi-switching installations. Instantaneous "make" and "break" snap-action of the three poles is independent of the speed of actuation—even extremely slow moving cams can be used.

The K3-4 Series offers designers a wide variety of 3-phase circuit hookups for servo-controls, to limit movement of machine members and as a start-and-stop switch which formerly were possible only with complicated relays or a number of separate switches. A large selection of standard actuators is available.

Small basic switch is low cost; directly interchangeable with AN3234 Specs



F2 SERIES

These Electro-Snap F2 Series snap action switches are extra-compact with extremely high electrical capacity for their size. Mechanical and electrical life at 1/32" overtravel is 150,000 operations, minimum, with accurate repeatability and constant stability of tolerances. Self-aligning springs provide contact wiping action rare in a switch of this size.

Durable case of special plastic gives the switch an ambient temperature rating of —100° to +275° F. or +375° F. Available, *at low cost*, in three basic models with a wide selection of actuators.

SERIES F2 BASIC SWITCH: F2-3: Single Pole, Double Throw
F2-2: Single Pole, Normally Open; F2-1: Single Pole, Normally Closed

OPERATING CHARACTERISTICS

Electrical Rating: 10 AMP. 125/250 V. A.C. 60 cycles
30 V. D.C. inductive and resistive (6 AMP, 30 V. D.C. for Airborne Application)
Operating Force, 7 to 12 oz.
Reset Force, 4 oz. Min.
Pretravel, 3/64 Max.
Movement Differential, .011 ± .005
Overtravel, 1/32 Min.

SEND COUPON FOR MORE DATA

ELECTRO-SNAP SWITCH & MFG. COMPANY
4252 W. Lake St., Chicago 24, Ill.

Please send data sheets on switch checked:

- ☐ EF-3 — subminiature sealed
- ☐ G3 — 40 Amp. basic
- ☐ K3 — Triple-pole
- ☐ F2 — Extra-small basic

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Avco makes things better for America...

Avco

Avco Manufacturing Corporation
420 Lexington Avenue, New York, N.Y.

letters

Adland Revisited

To the Editor:

It may come as a surprise to some of your readers that space is for sale and that a professional group of "space salesmen" exists. I don't, of course, refer to the kind of space that rockets are designed to overcome. I'm talking about the kind of space you were good enough to lend Mr. A. Swoboda last month for an auroral display of ignorance about advertising and the people who write it. Space salesmen of any publication will fail to confirm his assertions.

It's hard to be sensitive about stuff like his bit about "advertising writers suddenly becoming experts and dispensing hogwash," but I'll do my best. First of all, it would seem worse than futile to try to misinform technical men. And then, an advertisement is an important business investment. The people who invest in space, words and art in order to sell their products or services rarely care to see their money float away in hogwash.

Advertising men are not born very differently from other members of the human race, nor are they swaddled in grey flannel. Those I know are very hard working, unpretentious and competent people, with not even a sincere tie to distinguish them. While they may not be experts, they try to know all they can about the products they sell.

For myself, I have always had a soft spot for the guided missile, ever since I engaged in a years-long project for the evaluation of all missiles work done by Germany. It was my privilege and pleasure to translate a large chunk of the work on this subject done by the Russians. The fact that I now write advertising copy for a basic material which is indispensable in both guidance and plumbing systems may be entirely accidental. It would pain me to believe that similar accidents are not to be met with among advertising writers. Thanks for the space.

Andrew Certner
New York City, N.Y.

Coming Up

To the Editor:

As a British subscriber to m/r, may I congratulate you on a fine magazine. I wonder if we can look forward to an issue on missile control systems (hydraulic/pneumatic actuated etc.), sometime.

D. A. Parrish
18 Arundel Road
Hollywood
Worcestershire, England

We are planning an issue on missile components and subsystems to be published in May 1958.—Ed.

Historical Correction

To the Editor:

We were pleased to note your excellent summary of the *Dart* missile (m/r, July 1957, p. 128), for which the H. A. Wagner Co. has designed and developed the guidance system. However, one historical point should be corrected.

Your article indicates that although the Germans had made a few test firings of a wire-guided missile, "they did not have much luck." Actually, the wire command link was fully developed for speeds up to Mach .85. For use with two missiles, the HS-293 and the *Fritz X*, a large number of sets were supplied to the front should the Allies start to interfere with the radio link. Since the Germans never detected such interference, the wire link did not come into use.

Dr. H. A. Wagner, President
H. A. Wagner Co.
14707 Keswick St.
Van Nuys, Calif.

Repeat on Reprints

To the Editor:

I truly believe you have established your magazine as a leader in the field. I look forward to every issue.

You started something that you may not be able to stop in granting copies of m/r cover reprints. I want a color reprint of the July cover of the Be X-IE. I would also like a reprint of th very excellent First Annual Guided Mis sile Encyclopedia to give my supervisor There is nothing like it. I too want t echo another letter to the editor reques ing a coverage of *research* missiles in th encyclopedia. I have enjoyed so man articles in the magazine that I would no dare try to list them, but I do want t make special mention of Dr. Wernhe von Braun's article, "Space Travel and Ou Technological Revolution."

Horace S. Solliday
Douglas Aircraft Co.
2717 Carnegie La.
Redondo Beach, Calif.

Thank you. A color reprint is bein prepared for you. Also, reprints of vo



Circle No. 15 on Subscriber Service Card.

Braun's excellent article will be mailed to you as soon as we get them from the printer. (We had to go to a second printing.) Reprints of the encyclopedia are in the mail.—Ed.

Wants Second Helping

To the Editor:

Several weeks ago you were good enough to send me 12 copies of the Guided Missile Encyclopedia, reprinted from the July 1957 issue of m/r.

At the time I requested these I was aware that it was an excellent and very informative compilation. However, I must admit that I completely underestimated the degree of interest that it evoked among our people here. I find now that I need about a dozen additional copies to satisfy the requests from our sales and management staff.

I wonder if you can help me with another twelve reprints?

Murray Heyert

Avien, Inc.
58-15 Northern Blvd.
Woodside 77, New York

In the mail—Ed.

Rocket & Research Societies Invite Queries

To the Editor:

In response to Mr. L. F. Megow of the Rocket Research and Development Society of Houston, who requested information on launching facilities, the Pacific Rocket Society and Reaction Research Society have a firing range in the Mojave Desert about 130 miles northeast of Los Angeles. Our facilities include a concrete block house, several launching towers, a 2000 pound static test cell, and two tracking stations. It would be a pleasure to answer any inquiries by serious amateurs regarding our facilities or the activities in which the societies are engaged.

Robert A. Citron
Pacific Rocket Society
Northrop Aeronautical Institute Branch

1155 West Arbor Vitae St.
Inglewood 1, Calif.

Plaudits for Dr. von Braun

To the Editor:

We wholeheartedly agree that Dr. von Braun's "Space Travel and Our Technological Revolution," published in your July issue, is extremely well done.

I wonder if you could give us some idea of what 200 reprints would cost. The writer is chairman of Immanuel Lutheran Parent-Teachers' Society here in Kansas City and it is our idea to send a copy of this to each parent.

Fred C. Stebbins
Aviation Sales Manager
Puritan Compressed Gas Corp.

Kansas City, Mo.

The response to Dr. von Braun's article has been overwhelming. Unfortunately our supply of reprints has been exhausted. The second printing is in the works and your copies will be in the mails as soon as they are available.—Ed.

Amateur Missileer Stymied

To the Editor:

Received my first issue of m/r and was much pleased with its extended coverage in the rocket field. However, I understand from other subscribers that you have available an introductory issue composed of various subjects taken from past issues. This I would very much like to receive.

The question "Why doesn't American Rocket Society set up a missile launching base for amateur missileers," in Missile Miscellany, is one the undersigned and a lot of other people would like to have an answer to. I can name a hundred missileers who would give a month's pay to have a place to test their hardware.

Just in our small group on Project *Vanguard* we have home-built projects using anything from black powder to UDMH and from six inches to 16 feet. The big question is not EST etc., but where can we test and fire these jobs? We can't find the answer. Can you? We have a rocket ready to fire now employing as much range safety and tracking gear as *Vanguard* itself, but that doesn't give us permission to run the countdown. If you can give us any assistance toward a launch site, please do.

Harry R. Sampsey

31-48 78th St.
Jackson Heights, N.Y.

Try a local university. Also, consult Prof. S. Fred Singer, Physics Department, University of Maryland, College Park, Md. See Mr. Citron's letter, this page.—Ed.

New Bendix SM-E Connector

(smaller, lighter than AN-E but equally dependable)

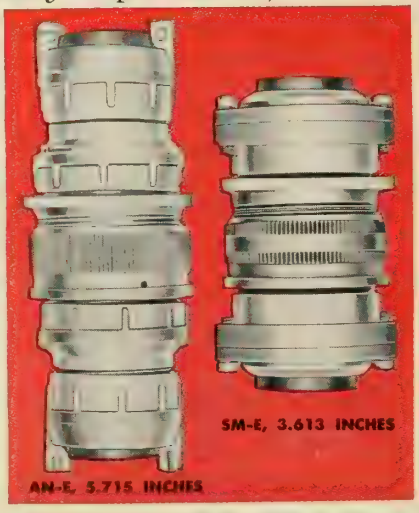


Here is the newest in the ever growing family of Bendix* environment resistant connectors. The new SM-E Series (Short "E") will provide the same performance as the standard AN-E connectors, but is shorter, lighter and more easily serviced. Not only does this connector conform to the vibration resistant requirements of the "E" connector in the MIL-C-5015C government specification, but it also provides effective moisture barriers both at the solder well ends and mating surfaces using the full range of wire sizes. Of particular interest to production and maintenance people is the back nut design, which provides a jacking action on the grommet during disassembly, thereby lifting it free of the solder wells. This feature when combined with the new Bendix "slippery rubber" grommets makes easy work of wire threading and grommet travel over the wire bundles.

Available in all standard AN shell sizes and tooled for most of the popular AN configurations.

Write for complete descriptive folder.

*TRADEMARK



Comparison based on size 40 mated assemblies. Space savings for smaller sizes are proportional.

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The story is in this book...

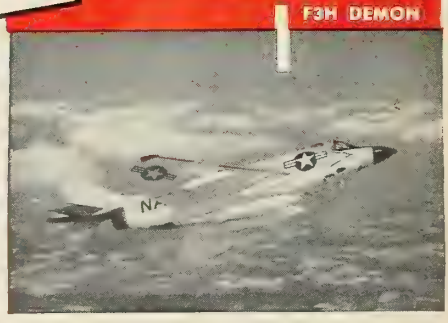
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- **completely integrated facilities in St. Louis (with pictures of our ultra-modern engineering campus).**

Naturally, our engineering application form will be enclosed along with a copy of our pamphlet "St. Louis, A Good Place To Live." This pamphlet is packed with valuable data on living conditions in the St. Louis area.

***As of 30 June 1957*

To: Raymond F. Kaletta, Tech. Placement Supvr.
Box 516 c/o MAC
St. Louis 3, Missouri

Please send me a copy of the McDonnell Aircraft Annual Report for Fiscal 1957

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Address _____

College attended _____

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Provides timing lines, record numbering and many other advancements

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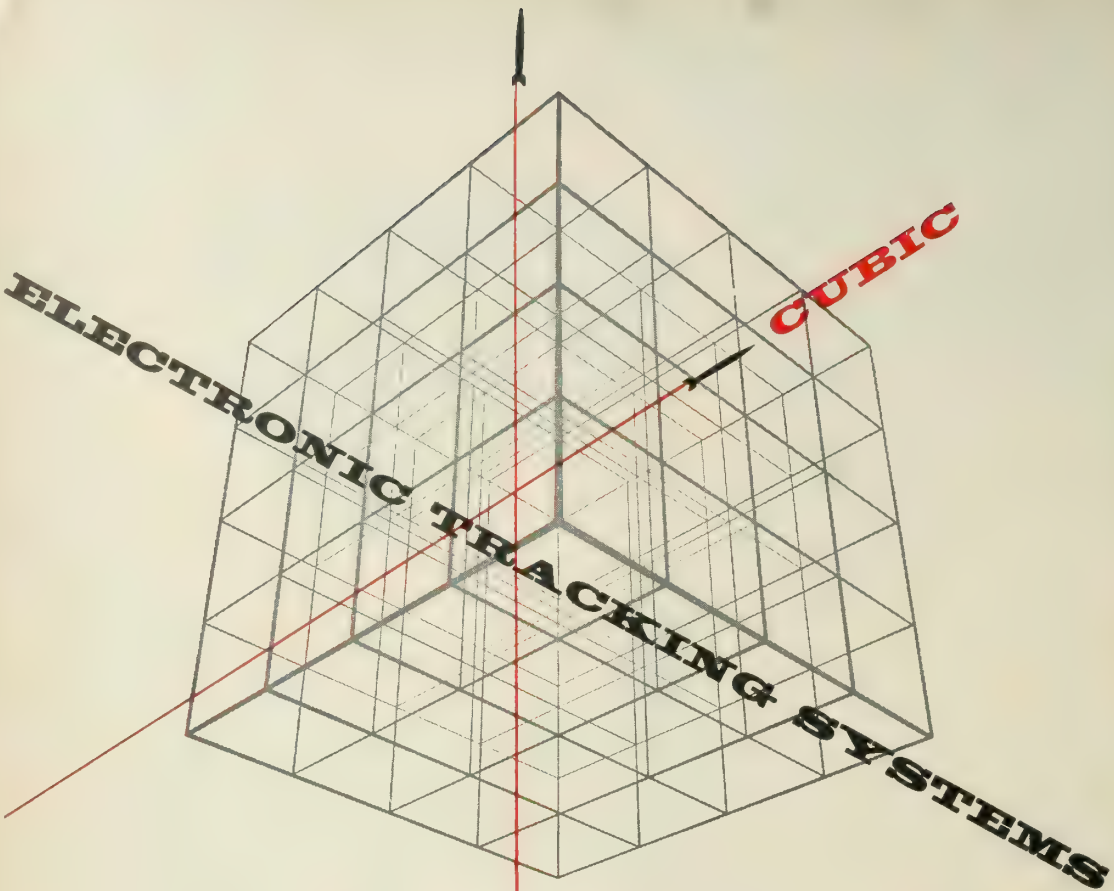
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P. O. BOX 7186 TULSA, OKLAHOMA

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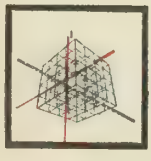
standard deviation: 2 ft at 200 miles

acquisition: automatic and omnidirectional

airborne package: less than 0.01 cu ft

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UNITED STATES AIR FORCE

MISS-DISTANCE MEASUREMENT
MISSILE GUIDANCE
BOMB-SCORING
AIR TRAFFIC CONTROL
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REDUCE WEIGHT
SAVE SPACE
IMPROVE PERFORMANCE
in Airborne Communication and Navigation Equipment



shown actual size
10 Mc Hycon Crystal Filter

HYCON EASTERN, INC.

75 CAMBRIDGE PARKWAY CAMBRIDGE 42, MASSACHUSETTS

To Designers of Aircraft and Missiles:

The July 24th issue of "The New York Times" described a new radio and radar component no larger than a cigarette lighter that simplifies the design of complicated electronic equipment. Known as the high frequency crystal filter, it is unaffected by abrupt temperature changes and repeated heavy shock and vibrations.

These units permit excellent reception in the presence of strong jamming or interfering signals. Maintenance is reduced to almost zero and alignment in the field is eliminated. Center frequencies are accurate to .001%. Insertion loss is 1/10 of other filtering methods. Aircraft and guided missile environmental requirements are exceeded.

Our Company has pioneered in the development of crystal filters. A number of standard models are currently in mass production. Many manufacturers of radio and radar equipment have developed improved systems utilizing Hycon Crystal Filters. It will pay you to ask your sub-contractors how this unique component can make your missiles or aircraft a more effective weapons system. If they are not familiar with the advantages of crystal filters, we can help you. A request on your company letterhead will receive a prompt reply.

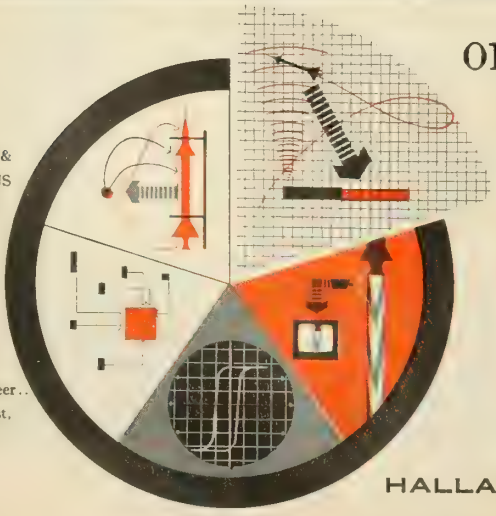
Cordially,

Malcolm M. Hubbard

Malcolm M. Hubbard
President

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on target insurance

There is only one "good landing" for an armed missile...ON TARGET. Hallamore designed and produced missile instrumentation and guidance checkout systems calibrate and report prefiring conditions to assure the efficient performance of some of the latest vehicles in the missile field. Hallamore Electronics performs contracts for the United States armed forces and prime contractors of the aircraft and ordnance industries. Its field of activity includes missile ground support and in-flig instrumentation systems, audio and visual communications systems, magnetic products and electronic components.

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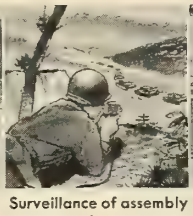
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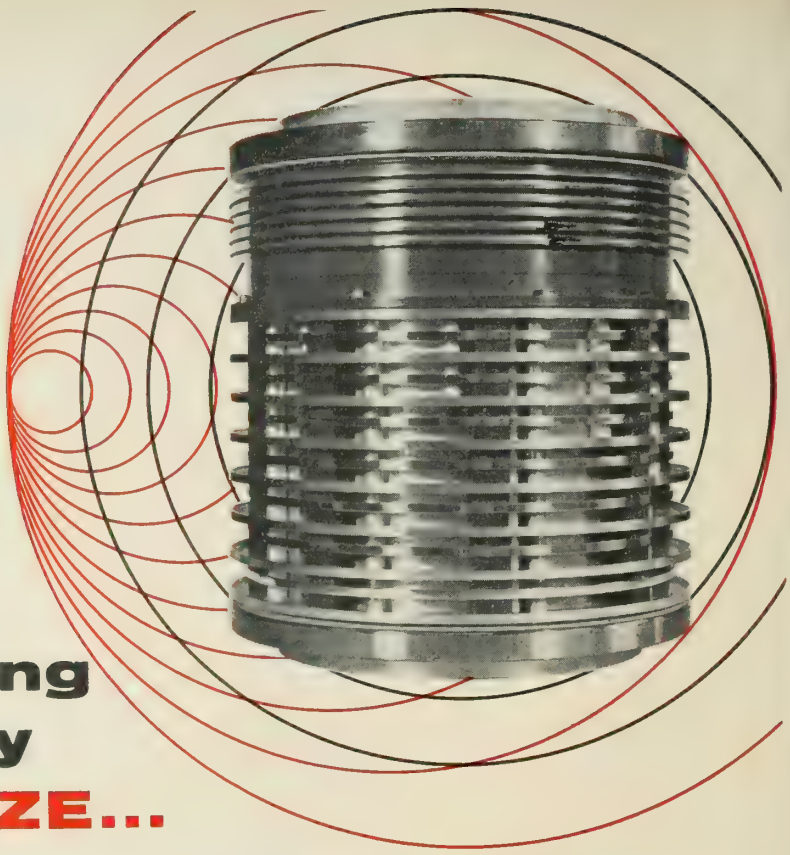
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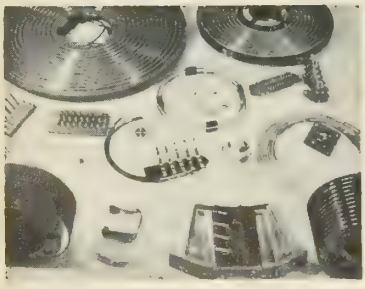
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OCTOBER

ASME-ASLE, Joint Conference, Hotel Royal York, Toronto, Canada, Oct. 7-9.

NACA Lewis Propulsion Lab. Triennial Inspection, Cleveland, Ohio, Oct. 7-10.

International Astronautical Federation, 8th Annual Conference, Barcelona, Spain, Oct. 7-12.

ARDO Fifth Annual Science Symposium, Interdepartmental Auditorium (across street from AFOSR hdqrs), Host Center: AFOSR, Washington, D. C., Oct. 8-9.

Society for Experimental Stress Analysis Nat'l Fall Convention, El Cortez Hotel, San Diego, Calif., Oct. 9-11.

National Noise Abatement Symposium, Sherman Hotel, Chicago, Ill., Oct. 10-11.

ASME Fuels Div. and AIHE, Joint Conf., Chateau Frontenac Hotel, Quebec, Canada, Oct. 10-12.

National Society of Professional Engineers, Fall Mtg., Grand Pacific Hotel, Bismark, N. D., Oct. 17-19.

ASME Conference on New Developments in the Field of Power, Americus Hotel, Allentown, Pa., Oct. 21-23.

Canadian Aeronautical Institute/IAS Mtg., Montreal, Canada, Oct. 21-22.

Computer Applications Symposium, sponsored by Armour Res. Foundation, Morrison Hotel, Chicago, Ill., Oct. 24-25.

Association of the U.S. Third Army Annual Mtg., Sheraton-Park Hotel, Washington, D. C., Oct. 28-30.

IRE, Engineering Writing and Speech, First National Symposium, Sheraton-McAlpin Hotel, New York, N. Y., Oct. 21-22.

American Nuclear Society, Henry Hudson Hotel, New York, N. Y., Oct. 28-31.

National Industrial Packing and Handling Exposition, Convention Hall, Atlantic City, N. J., Oct. 28-31.

IRE, East Coast Aeronautic and Navigation Conference, Baltimore, Md., Oct. 28-29.

IRE, Annual Technical Meeting, Electron Devices Group, Washington, D. C., Oct. 30-31.

NOVEMBER

Joint Military-Industry Guided Missile Reliability Symposium (security clearance required), Naval Air Missile Test Center, Pt. Mugu, Calif., Nov. 5-7.

IAS Weapons System Management mtg., Statler-Hilton Hotel, Dallas, Tex., Nov. 7-8.

IRE, Instrumentation Conference and Exhibit, Atlanta, Ga., Nov. 11-13.

Vickers Aircraft Hydraulics Conference, Park Shelton Hotel, Detroit, Mich., Nov. 12-13.

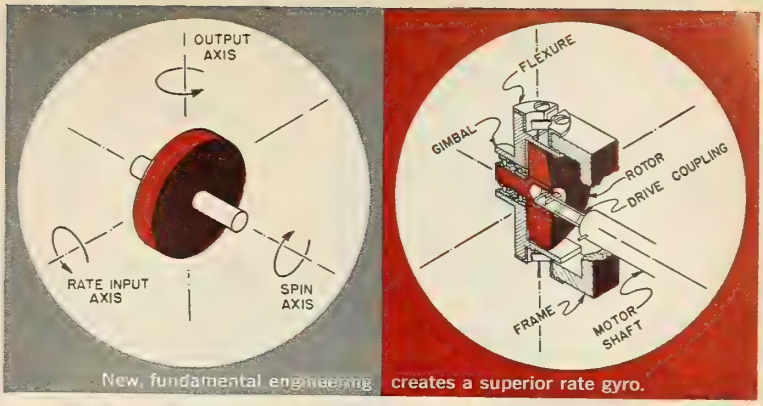
National Plastics 8th Exposition, International Amphitheatre, Chicago, Ill., Nov. 17-21.

DECEMBER

ASME Annual Mtg., Hotel Statler, New York, N. Y., Dec. 1-6.

American Rocket Society Annual Mtg., Hotel Statler, New York, N. Y., Dec. 2-6.

ARS 1957 Eastern Regional Student Conf., sponsored by the Polytechnic Institute of Brooklyn Chapter, Hotel Statler, New York, N. Y., Dec. 6-7.



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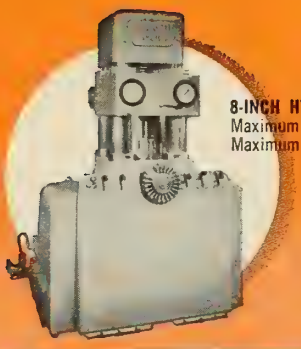
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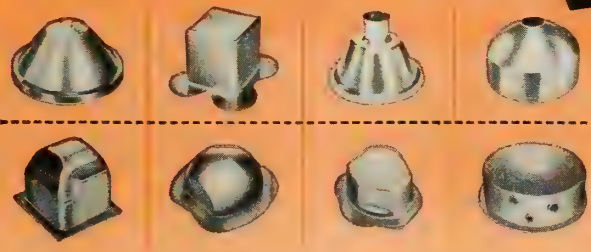
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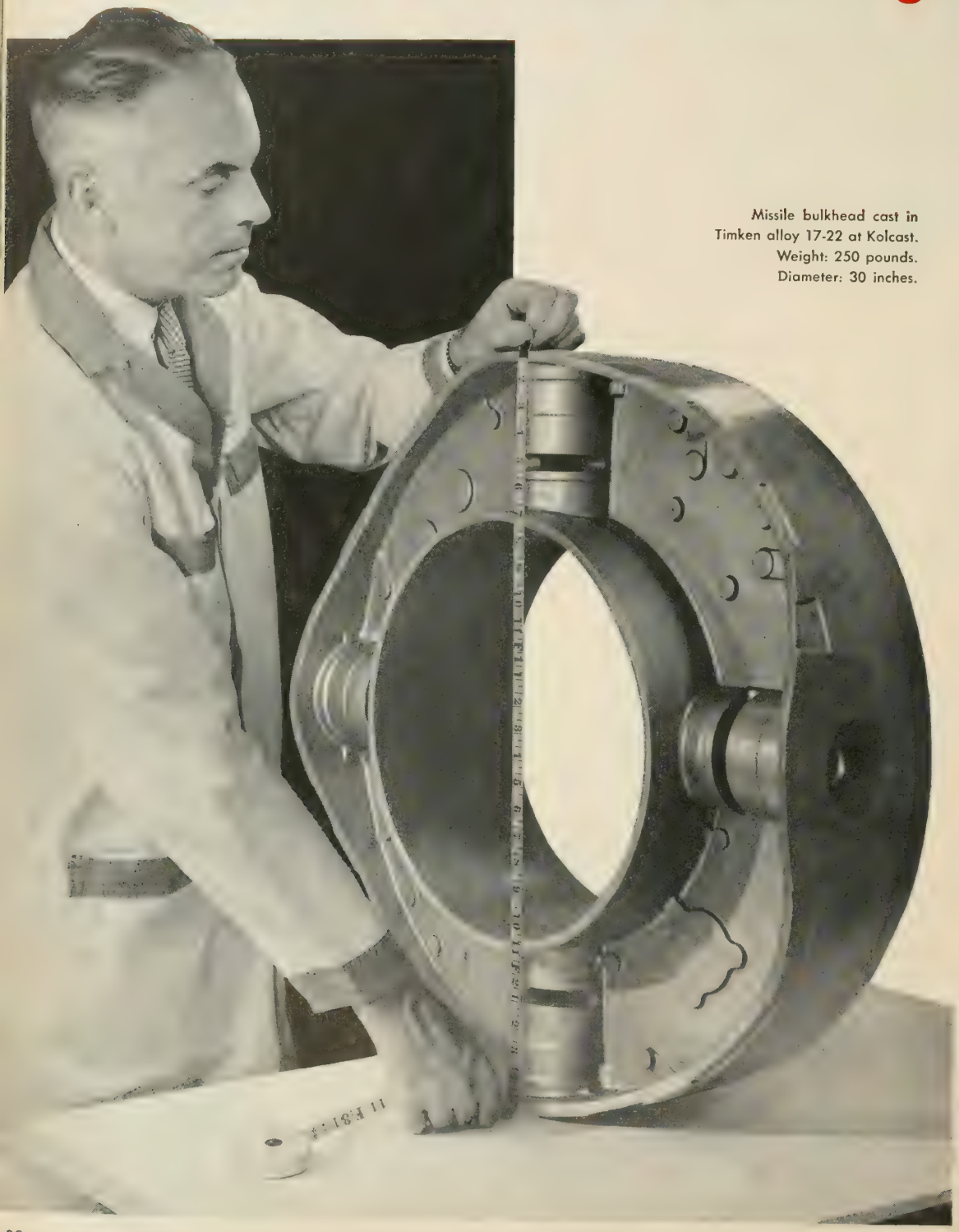


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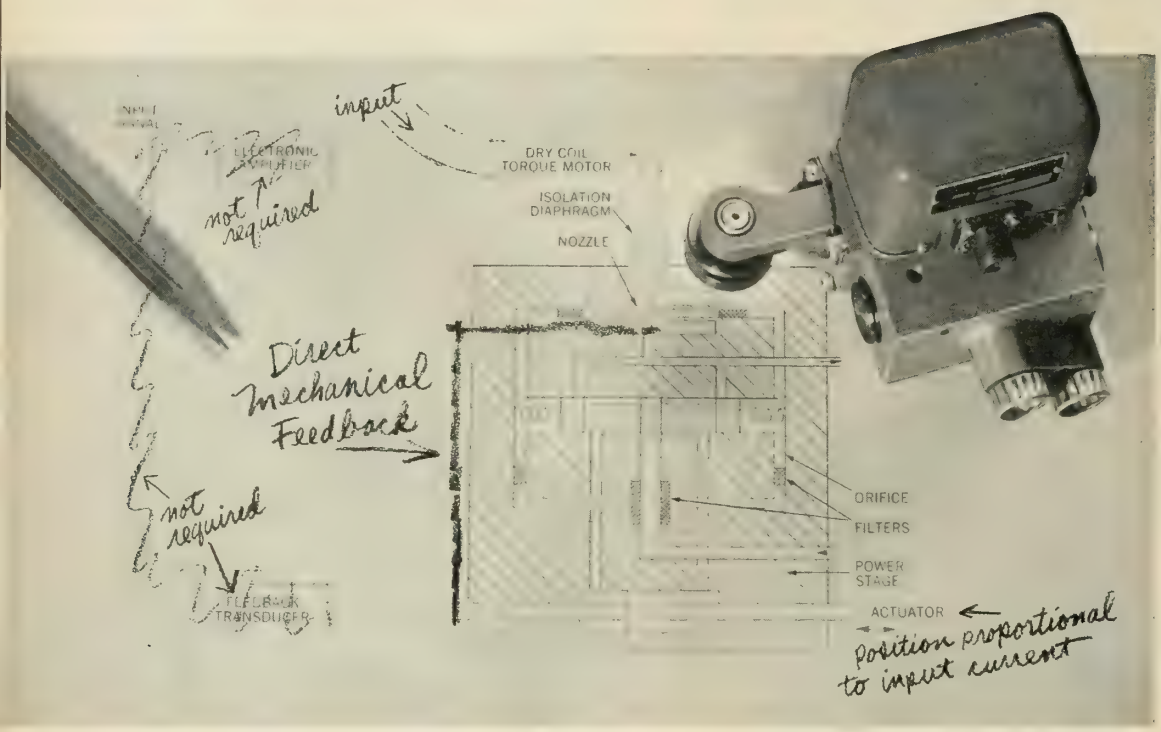


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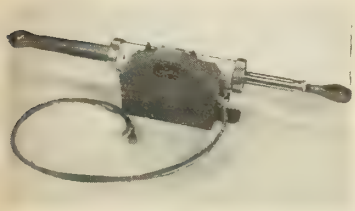
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The unit illustrated above has a ¼" stroke with .16 watt electrical error input. It is in production. The design may be modified to any desired stroke, with inputs of .06 watts and lower. Hydraulic Research's new servo system design utilizes a basic dry coil torque motor servo valve. It is compact, lightweight, and adaptable to any application where precise positioning is required.



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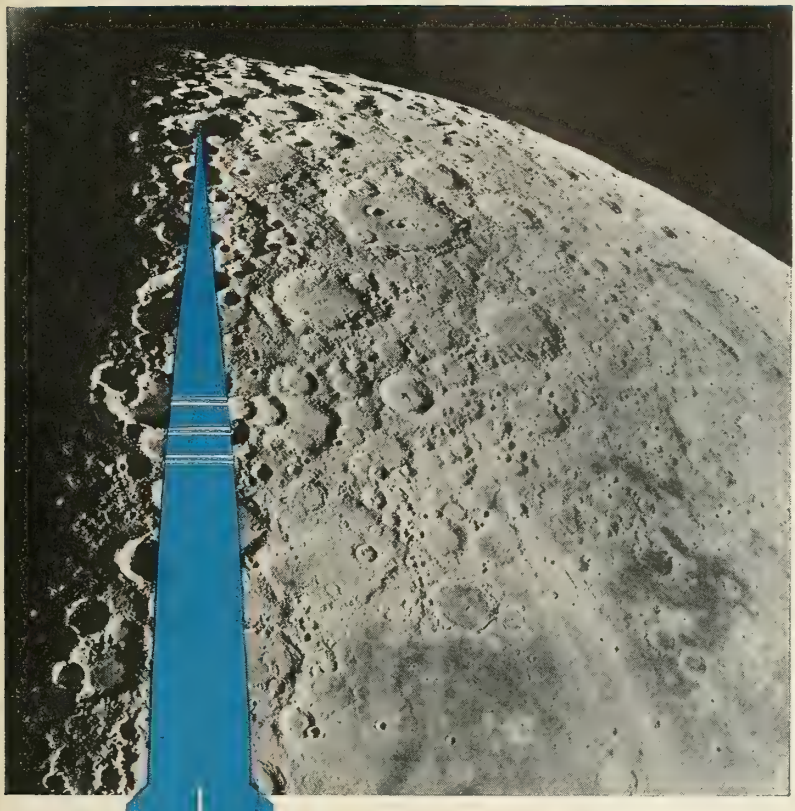
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Inter-Planetary Ballistic Missiles

IPBMs May Mean Safe H-bomb Tests

Build Inter-Planetary Ballistic Missiles and use the moon as a safe, profitable test site for H-bombs—this suggestion from Maryland University's Dr. S. Fred Singer at the Eighth Congress of the International Astronautical Federation in Barcelona, Spain, October 7-12. Dr. Singer is one of the original proposers of the *Far Side* space exploration rocket project now underway at Eniwetok.

As m/r goes to press, leading rocket, missile and space flight scientists, engineers, lawyers and editors from all over the Free and Communist worlds are meeting to read papers and discuss the latest state of the space-flight art—including everything from space law and moon rockets to IPBMs.

Dr. Singer, in a detailed technical paper, demonstrates the feasibility of testing missile-launched H-bombs on the moon. He insists that not only will this free the earth of any danger from radioactive fall out, but it will provide valuable scientific data as well. Some of the debris kicked up from blasting craters on the moon may result in dust particles and even boulders bombarding the earth. The latter would be large enough to be recovered pretty much intact. Study of these "moon samples" would provide valuable data on the history and current state of the solar system. Significantly, Dr. Singer suggests that nuclear bombs will soon become too big for safe testing on earth. "It is difficult to predict what will happen when we 'progress' to the point where a truly cosmic bomb can be produced, but since such a development is inevitable, we might as well face it."

Astrophysicist Singer argues that sending an IPBM to the moon 240,000 miles away will be no more of a technical problem than launching an ICBM 5000 miles. He points out that there will be a great weight-saving since it will need neither a heavy reentry nose cone nor such highly refined guidance as does the ICBM. The moon is an easier target than a city. He also notes that development of IPBMs is inevitable.

Advantages of this proposal include: "A good record of the power of the H-bomb for all to see;" lack of the need for expensive, space-consuming test ranges; less dependence on weather conditions for test shots; and new craters which will provide "unique opportunities for perpetuating the names of presidents, prime ministers and party secretaries." In addition, of course, there are numerous scientific benefits to be derived including the theories of meteor craters; study of meteoric-dust effects on the earth's weather; study of the motion of interplanetary gas with respect to the earth, study of magnetic and electrical phenomena, etc.

The moon missile's peak velocity would have to be 35,000 fps to escape the earth's gravitational field and fall into that of the moon. This is 40 per cent higher than satellite velocity. The point of light from an H-bomb flash on the sun would be twenty times as bright as a similar point of light on the moon. A 100-megaton bomb would blast a crater on the moon's surface 12,500 feet in diameter and 1800 feet deep. A 1000-megaton bomb would dig a hole 25,000 by 3000 feet. This compares to Clavius, the largest natural moon crater, which is 146 miles across and 16,100 feet deep.

Other papers at the Barcelona Congress include a treatise on space law by Andrew G. Haley who has been nominated as the next president of the IAF; and another by Darrell Romick on *Meteor Junior*—"A Preliminary Design Investigation of a Minimum-Sized Ferry Rocket Vehicle of the Meteor Concept."

Space lawyer Haley points out that even as space vehicles will bear little resemblance to their airborne, earth-bound cousins, so must whole new legal concepts be developed when "up" become "out" and when, eventually, living beings are found on other planets. Haley refers to his legal theories as metalaw.

Haley cites the self-evident fact that there is a difference between non-military, scientific satellites passing over some one else's sovereign territory—as will be the case with the IGY satellites—and a larger vehicle with direct military potential. He points out that we are on the verge of having to begin to think about the answers to these questions that will soon be critical in international, and interplanetary law. He also suggests next steps.

Rocketeer Romick presents in engineering detail a proposal for landing men on the moon's surface and getting them back again for a total cost of $30 million. Co-authors with Romick were Richard E. Knight and Samuel Black. All are with the Goodyear Aircraft Corp.

Navy *Polaris* Test Vehicle Fired

The first flight of the Navy's *Polaris* FBM was made from Cape Canaveral during the third week of September, and was described in an unconfirmed report as a "highly successful" flight.

Designated a test vehicle, it is believed to have been a two-stage configuration. Thiokol Chemical Corp. under contract with Army Ordnance is supplying full scale test missiles. Lockheed is prime contractor. Thiokol has a contract for at least six *Polaris* test vehicles.

The first stage consisted of two or more solid-propellant motors reported to be modified *Sergeant* surface-to-surface powerplants. The second stage, utilizing the latest principles in solid propellant development, was a single unit.

The new techniques employed in the second-stage motor of the *Polaris* test vehicle are considered a major breakthrough in the field of solid propellants. The motor exhausts into a high-pressure plenum chamber, which then directs the gas through four small nozzles. Four additional nozzles, spaced between the other four and turned to exhaust in the direction of missile travel, serve as pitch, yaw and nose-cone-separation control.

The ability to gimbal a solid-propellant motor has not been reported a state of the art. This leaves only two methods of control known to solid-propellant engineers—fins and venting. Fins are functional only when operating in the atmosphere. A *Polaris* FBM traveling 800-1500 miles would, during the later phase of its powered flight,

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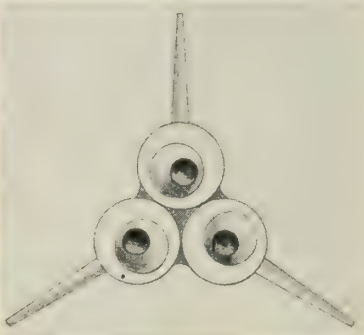
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be operating at extreme altitudes above appreciable atmosphere. Therefore, a vented rocket system appears to be the only answer at this time.

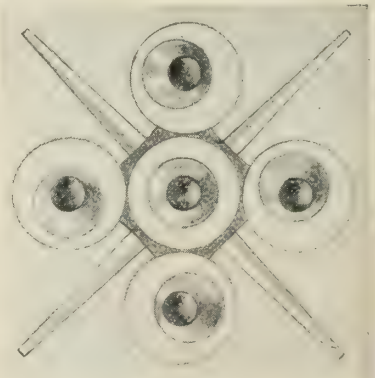
Another major problem with solid-propellant rockets has been the decay of specific impulse and the inability to control precisely the velocity at burnout. This is a critical problem in ballistic missiles because the velocity at burnout determines the point of impact. Nozzles exhausting against the direction of travel will insure clean separation of the nose cone at the instant it is needed. Details of how such a missile



Aft view of possible arrangement of an 800-mile POLARIS test vehicle. Three solid-propellant rocket motors with canted nozzles arranged to impart spin during boost.

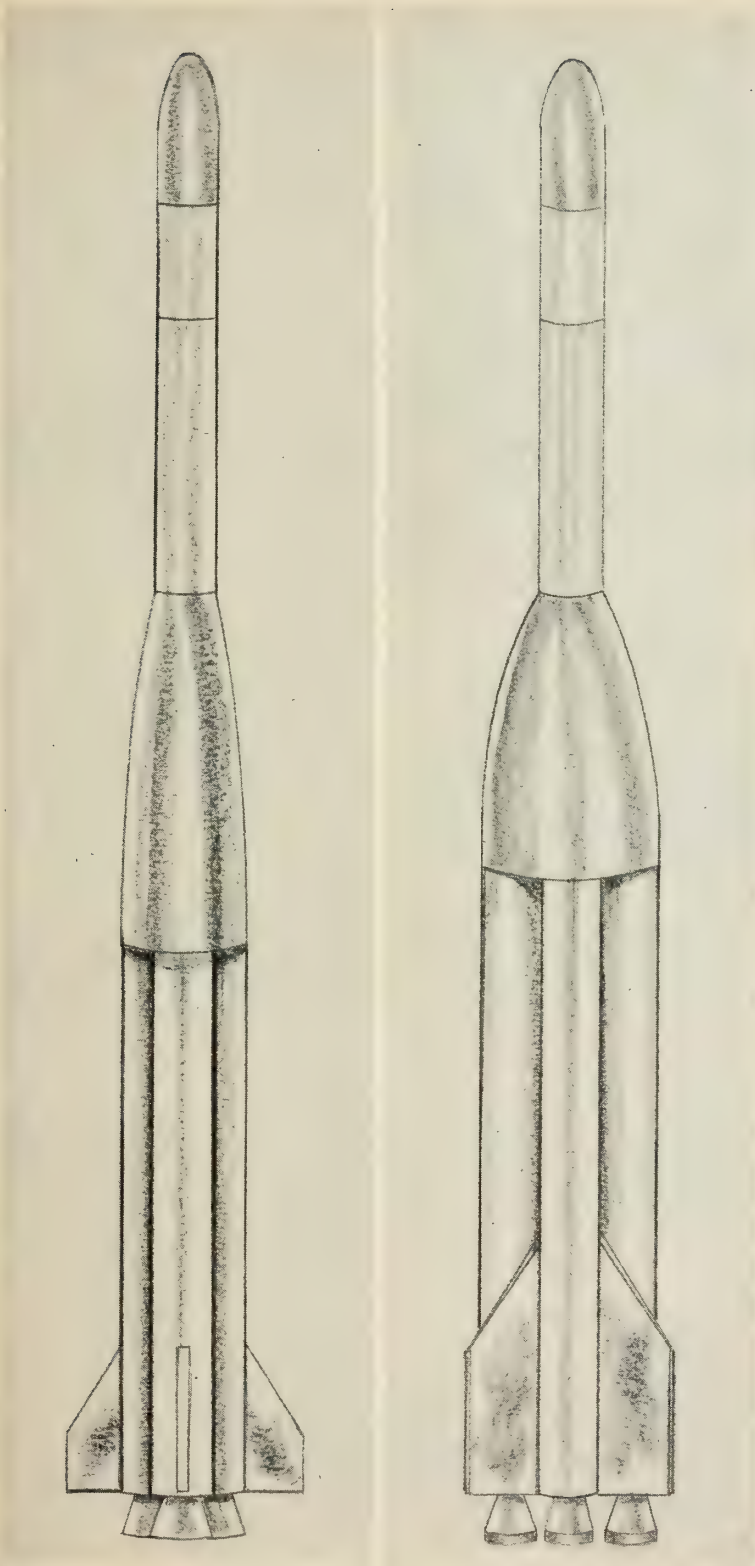
will be controlled in roll and the pitch and yaw plane of references is not known.

The *Polaris,* designed to be fired from submarines and surface ships, will necessarily have to use zero-length launch pads. For this reason the first stage will probably be fin- and spin-stabilized similar to the X-17. The



Aft view of the booster section of a possible arrangement for a 1500-mile POLARIS test missile. Center rocket could either be second stage of three-stage configuration or fifth booster rocket of possible two-stage model.

Polaris test vehicles are estimated to be four to six feet in diameter and 50 feet in length. Lockheed is currently using the X-17 on a separate *Polaris* test program.



Shown in an artist's conception are possible staging arrangements for the POLARIS test vehicles. Shown are an 800-mile test vehicle (left) and a 1500-mile version (right).

Snark Missile Squadron To Be Activated

Air Force has announced that the first *Snark* guided missile squadron will be activated late this year.

This will be the first intercontinental guided missile to come in to operational use. An aerodynamic cruise missile, it will travel at subsonic velocities.

The squadron, to be assigned to the Strategic Air Command, will be equipped with the high-altitude, jet-propelled missile, which is capable of delivering a nuclear warhead.

The *Snark* SM-62, manufactured at the Northrop Division of Northrop Aircraft, Inc., at Hawthorne, Calif., is the first intercontinental missile to go into production for the Air Force.

Commander of the squadron will be Lt. Col. Richard W. Beck. Currently assigned to SAC's directorate of operations, Col. Beck formerly commanded a B-47 bombardment squadron at Lockbourne AFB, Ohio.

The exact site for the new missile unit has not been named at this time. SAC officials emphasized that missile units will be so positioned as to reduce problems of noise and to insure that missiles, if ever fired, will not pass over heavily populated regions.

Plans call for no missiles to be launched from operational sites except in case of war. For training purposes, missile crews will practice actual firing at an established range such as Patrick Air Force Base, Fla.

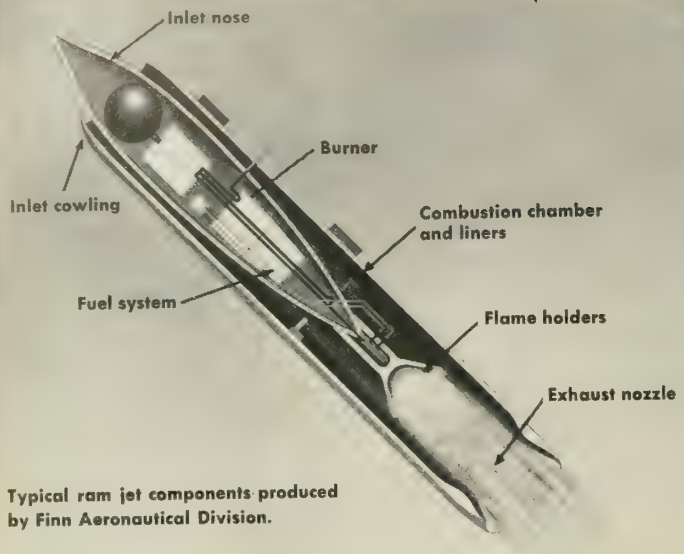
The missile squadron will be manned by some 500 officers and men. Personnel are now undergoing special training in the operation and maintenance of the *Snark* at Northrop's plant in Hawthorne.

Nike-Zeus On the Way

The U.S. Army Ordnance Corps is pushing hard on development of the *Nike-Zeus* system as a logical improvement of the up-and-coming *Nike-Hercules*. The *N-Z* would have a slant range of over 100 miles, be able to carry a nuclear warhead, and is to counter targets in the Mach 2, 50-75-thousand-foot altitude class.

Zeus would put the Army close on the heels of the Air Force *Bomarc* cruise missile. Thus, Ordnance Corps wants to progenerate the AAC by introducing a competing missile in the ground-to-air defense spectrum. In addition, there have been hints that *N-Z* could evolve into an anti-missile to counter the Soviet ballistic missiles.

Various designs for *N-Z* have



Typical ram jet components produced by Finn Aeronautical Division.

been leaving the drawing board at a fast rate while systems development is being carried out at Redestone Arsenal and other facilities. Indeed, some components are well beyond the drawing board and are entering the test phase.

Thiokol Has Tried Large Solid Rocket

Thiokol at Huntsville is said to have static-fired a large solid-propellant motor which may be the *Zeus*. The Army is known to favor an all-solid-propellant powerplant—possibly an ammonium nitrate-polysulfide formulation. The reason for this may be the rapidity with which Thiokol turned the *Hercules* design into production. It is felt that as soon as test firings and engineering analysis have been completed, the Army will push for adoption of this new weapon, claiming better reliability and lower cost than *Bomarc* and more versatility than *Hercules*.

Specification Breakdown

Speculators hint that *Zeus* may have the following makeup:

- Short-fat design to minimize center of gravity changes. This design would also facilitate handling and allow present equipment and storage facilities to be utilized with little modification. The large-diameter configuration would also allow the use of high-yield nuclear warheads for anti-missile use. An alternate design suggested uses the telephone-pole configuration.
- Single-stage, high-thrust motor, possibly with built-in program of high-thrust boost and lower-thrust level for cruise. Total burning time would be 30-60 seconds using an uncooled motor.
- Extensive use of lightweight alloys. Case bonded, internal-burning grain to permit high mass ratios. Protective insulation (burnaway liners, phenolic glass inserts, and Rokide-coated nozzle).
- Canted nozzles for spin-stabilization.
- Plenum chamber and combustion gas bleed to provide for auxiliary jet altitude control.
- Combustion cut-off achieved via cartridge-actuated vents to drop pressure and, hence, snuff out burning.
- Total loaded motor weight of two to four tons with motor volume of *Hermes* RV-A-10 proportions.

Since solid-propellant operation is expected, the system could probably be completed and ready for evaluation within a year. At this time, therefore, the Army can be expected to push hard for budgetary favors in getting *Nike-Zeus* into operation.

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Moon Cities Planned By Red Civil Defense Chief

N. A. Varvarov, chairman of the astronautical section of Russia's civil defense organization, has revealed plans for future Soviet cities which, he says, the government of the Soviet Union will build on the moon by early next century.

According to Comrade Varvarov, the future Red lunar city will have an artificial atmospheric pressure enabling humans from the earth to survive and even thrive on the moon. It will be a pressure one-third less than now present on the earth at sea level, but it will contain more oxygen so that man will be "able to breathe without any unpleasantness for his health."

The Red city will be built in one of the lunar craters, under a tremendous dome of glass and supplied with aluminum doors or "air-locks." Inside, at every half-mile or so, the city will be partitioned by glass walls with double doors. These will minimize the damage that may result from falling meteorites or other accidents.

"We will find it too expensive to carry food from the earth to the moon," says Varvarov. "A loaf of bread on being transported to the moon will be worth its weight in gold. Therefore, our future lunar settlements will have to be self-sufficient insofar as food is concerned."

Because of the difference in gravity, all plants will grow fantastically when transplanted to the moon: "A radish will be as tall as a date palm on earth; onions will send forth sprouts 33-feet long."

The Soviet man of the future will build on the moon a number of solar- and atom-energy stations, with the aid of which the moon's light, water, and other necessities will be furnished. Aluminum, glass, plastics, oxygen and nitrogen will all come from lunar ores.

But the main industry of the future Red lunar settlements as envisaged by Varvarov will be the manufacture of space ships and of fuel for such ships.

Durant Named Assistant To Avco Lab Director

Frederick C. Durant III has been named executive assistant to the director of the Avco Research Laboratory, a unit of the research and advanced development division, Avco Manufacturing Corp.

Durant, a contributing editor to m/r and author of the Astronautics column, was formerly with Arthur D. Little, Inc.

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Left to right: S. S. Edwards, flight dynamics; B. W. Marsh, aerodynamics; M. Tucker, Aerothermodynamics Department manager; and R. L. Nelson, project aerodynamics, discuss reentry dynamics.

Lockheed MISSILE SYSTEMS

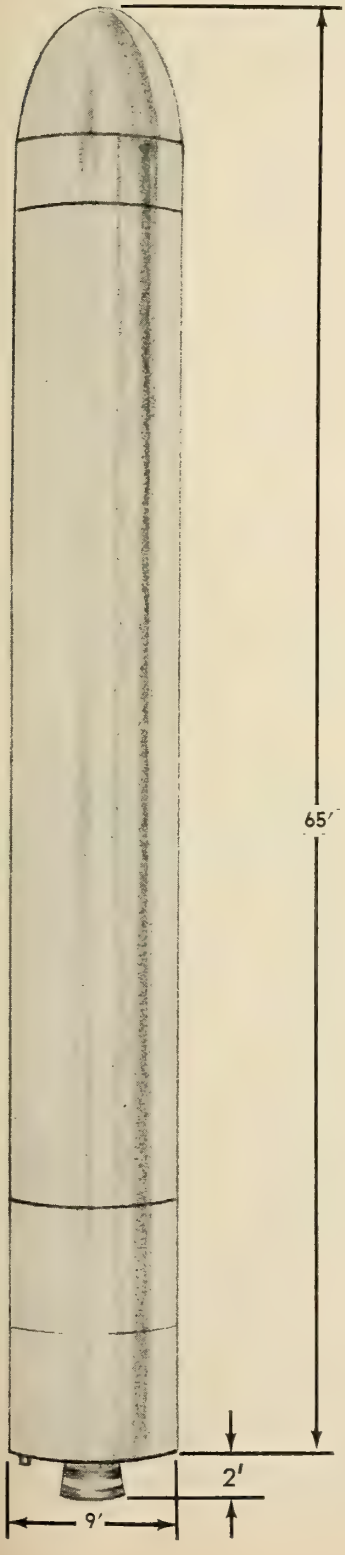
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Jupiter-Thupiter-Thorpiter-Thor?



The operational future of the *Jupiter* is a matter of tremendous speculation as m/r goes to press. Its future lies in the hands of the special Committee on Missiles Study comprised of William H. Holaday, special aide to the Secretary of Defense for Guided Missiles, Maj. Gen. John B. Medaris of ABMA, and Maj. Gen. Benjamin A. Schriever of the Air Force.

The committee's function: study the merits of the *Jupiter* and *Thor* programs and recommend either one or a combination of both. The committee met on Sept. 26th for a ten-day session. Officials have expressed confidence that a decision will be reached by the middle of October.

The decision will of necessity be based on many parameters. Not the least will be politics. Also important is the performance record in the check-out labs and during static and flight tests at Cape Canaveral. The latter have been well publicized by alert, observant members of the press.

On the basis of flight duration, the *Jupiter* leads.

If the nation's IRBM evolves from an integration of the two missiles, the question is: what components of each will be used? Also, how long will this increase the missile's development time?

Much is known about the two missile systems. Enough information is available at least to convince the missile engineer that an arbitrary decision based on overoptimism could be detrimental and should be avoided at all costs.

The *Jupiter* is a finless constant-diameter cylinder topped with a bluff nose cone for housing its nuclear warhead (see drawing). It is slightly over 60 feet in length and nine feet in diameter. The tank section is entirely constructed of welded heavy gauge aluminum. The lower engine section is heavily reinforced with longitudinal stiffeners to overcome engine vibration.

The guidance and control package, located in a small section above the alcohol tank, is a product of the Ford Instrument Co., a division of Sperry-Rand. The guidance gyros are air-lubricated and were developed by ABMA and FICo. The anti-slosh device, developed and adopted after failure of the first two *Jupiter* tests, is the ultimate in simplicity. Developed at ABMA, it was included in a flight *Jupiter* six days after conception.

An outstanding achievement of the project is the small auxiliary power gas generator which has undergone extensive testing at ABMA's component test lab. The early V-2 problem of freezing LOX valves was still plaguing ABMA engineers during the development of the *Redstone* and in the early stages of the *Jupiter* program. All new valves are now subjected to a "bath" of LOX for long periods before acceptance. Throughout the *Jupiter* development program Chrysler Corp. engineers have worked side-by-side with ABMA personnel in order to achieve switchover to production status with a minimum delay. Reports are Chrysler can be in production within four months.

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Radioplane XQ-4 (left) shown with the turboprop RP-77D drone and the RP-76 rocket drone.

Radioplane Drones Approach Flight Tests

Radioplane is scheduled to reach the flight test stage on one of its most important target drone developments shortly after the first of the year.

Two vehicles are involved, the high-altitude, rocket-propelled RP-76 and the turboprop RP-77DL. The two are to be matched for air-launch in Radioplane's Oscura flight service project for the Army.

The project gets its name from the Oscura Range in New Mexico, where Radioplane is to provide integrated flight and maintenance services in connection with the Army training of personnel in surface-to-air missile firing.

The Oscura contract is considered a highly significant step forward in the services provided to the military establishment by private industry and quite a feather in Radioplane's cap. It is one of the first contracts to call for flight operation of target aircraft by an industrial team for missile firing trials. Under its terms, Radioplane provides not only aerial targets and ground support equipment, but flight operators, a training program and maintenance service.

The final target drone will be the RP-76, a 300-pound plastic vehicle powered by an Aerojet 35-pound-thrust solid-propellant rocket motor. It will be carried aloft by the RP-77DL. The latter is powered by a Boeing 502-10E free turbine turboprop engine and is capable of 385 knots at 40,000 feet.

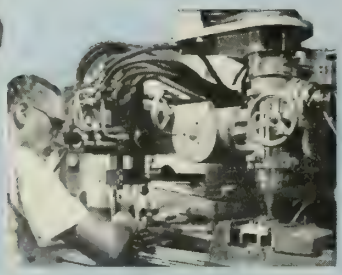
When a predetermined altitude is reached the RP-76 will be launched as a target for the *Nike* missile and the RP-77DL will be recovered by a parachute system. The RP-76 may also be recovered by the same method if it is not destroyed by the missile.

Both of the Oscura-project drones stem from Radioplane's RP-70, which was developed as a private enterprise with the company's own funds. A Navy version of the RP-76, called the XKD4R-1, has been delivered in evaluation quantities to Point Mugu. The RP-77DL is a later model of the RP-77D modified to carry a greater payload. Radioplane also is modifying the zero launcher designed for the RP-77D to permit attaching the RP-76 under the belly of the newer RP-77DL.

Lead time on the Oscura project is about 18 months, which means that actual operations on the *Nike* range will get under way about the first of 1959. Radioplane will establish headquarters for the project in El Paso, Texas.

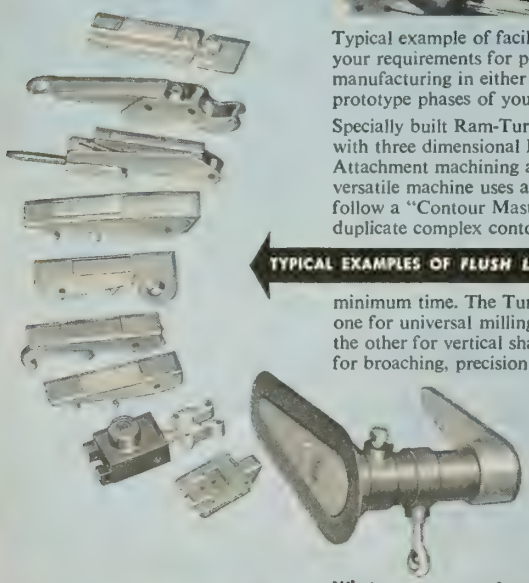
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Missile Firings Accelerated at Cape Canaveral

The last days of summer at Cape Canaveral went out with the smoke and roar of rocket engines. The launching pads on the Cape were a beehive of activity as the Army, Navy and Air Force stepped up the pace of missile firings during September.

During this period the "grand stand" location of the beach watchers less than two miles north of the launching area was constantly occupied. Reports indicate that most of the firings were successful—good news for many projects.

The most sought-after and the most heavily financed missile in this country's arsenal, Convair's *Atlas* ICBM, rebelled and marred the impressive September firing record. In a firing that fell short of the performance by the *Atlas* flight in June, the missile was destroyed less than a mile above the launching pad.

As in the previous flight, only the booster engines were being tested. Descriptions of the *Atlas's* flight behavior indicate that the engines suffered a propellant-flow interruption with a resultant falling off of thrust. The merger of the two exhaust flames into a single billowing mass, as the missile discontinued its vertical ascent, is indicative of propellant-line rupture. If this is what happened, the *Atlas* probably destroyed itself before the safety officer could respond. Meanwhile, *Atlas* number three is being readied for firing in the near future.

The *Thor* IRBM, one of the most controversial missiles in missile history, apparently made its first successful flight. Description and photos of the missile indicate that it is similar in configuration to its competitor, the Army-developed Air Force *Jupiter*. Major visual difference is the addition of small triangular fins discernible in the launch photos.

Advance reports on the *Jupiter-Thor* decision say missiles will be "married." Gen. Schriever has said that the two missiles are basically identical. Engineers close to the projects tend to disagree with Schriever's statement. Principle difference, in addition to the fins on the *Thor*, is in body outline and guidance components. The *Thor* has a tapering body in contrast to the constant-diameter cylinder outline of the *Jupiter*. This could create a major bottleneck when combining the missiles.

A newcomer to Cape Canaveral was the Navy's *Polaris* FBM. A staged test vehicle built by Thiokol, its firing was reported a complete success (see page 37).

The *Navaho*, determined to make its death glorious and prolonged, had its second successful firing. Both flights have been made since the project was cancelled. Five *Navahos*, in varying stages of completion, were at NAA's plant when the project was slashed. The $15 million attributed to the phase-out of the project apparently is being well spent.

Adding impetus to the firing tempo, a *Snark* intercontinental cruise missile blasted from its zero-length launcher in a smooth climb. Shortly after dropping its solid-booster rockets, it disappeared into a cloud bank. Two jet chase planes followed the *Snark* in what may have been a successful flight. The *Snark* will be activated into operational squadrons before the end of the year.

The *Bomarc*, long-range surface-to-air missile, made a high-climbing long-distance intercept flight over the Atlantic after an unhampered launching. This was the first successful firing against a jet drone aircraft. The *Bomarc*, a regular visitor to Cape Canaveral, will soon start rolling through production assembly in Seattle.

The Army with its spectacular successes in the preceding months was slightly overshadowed during September with only a *Redstone* firing. At least two more firings of the *Jupiter* are expected in the weeks to come.



Good news for the IRBM program—Air Force THOR leaves pad in first successful flight. Taper of body and small fins can be seen.

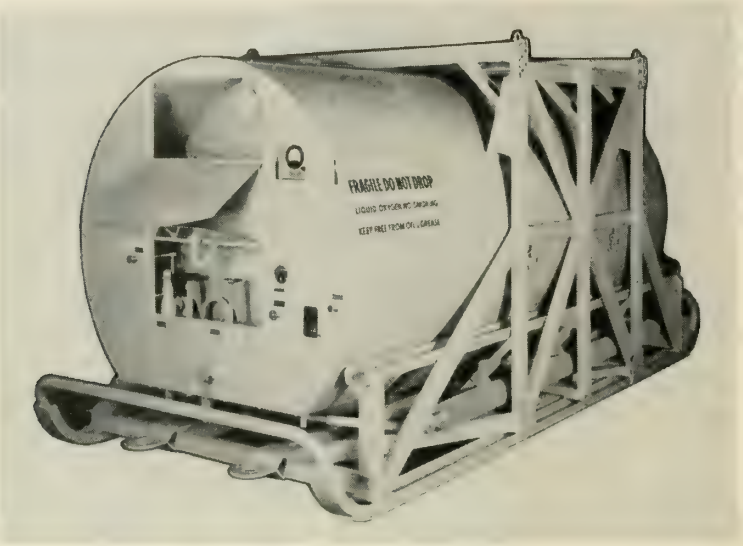




Bad news for the ICBM program—Air Force ATLAS rises above pad at Cape Canaveral in second unsuccessful attempt. The two booster engines thrust the ATLAS skyward (left). At 5000 ft. it makes tilt to east, flame increases, and seconds later it explodes.

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Army Activates First *Redstone* Group

HUNTSVILLE, Ala.—The Army's first heavy-missile group, equipped to use the 200-mile *Redstone* weapons system, was formally activated here on Sept. 18 under gray hurricane skies. It is the first unit to be fully equipped for combat use of the big missile developed here by Dr. Wernher von Braun and his team of former German scientists. It is the 40th Field Artillery Missile Group.

The backlash from Hurricane Esther held off long enough for an impressive ceremony, involving the 650 officers and men of the new group and a like number from Redstone Arsenal. to be carried out in the presence of the commander of the Army Ballistic Missile Agency, Maj. Gen. John B. Medaris, on the concrete airstrip of the Arsenal.

An unemphasized feature of the ceremony was the fact that five years of intensive research and development were required before this first armed *Redstone* missile group could become operational. But the historic significance was recognized far beyond the limits of this Southern city. The Associated Press sent a photographer because it had requests for pictures from as far away as Tokyo. All wire services, area dailies and television also covered.

For the 40th itself, the ceremony marked entry into a fourth dimension of warfare. Its unit colors have been carried into World Wars I & II, Korea and now into the age of missiles.



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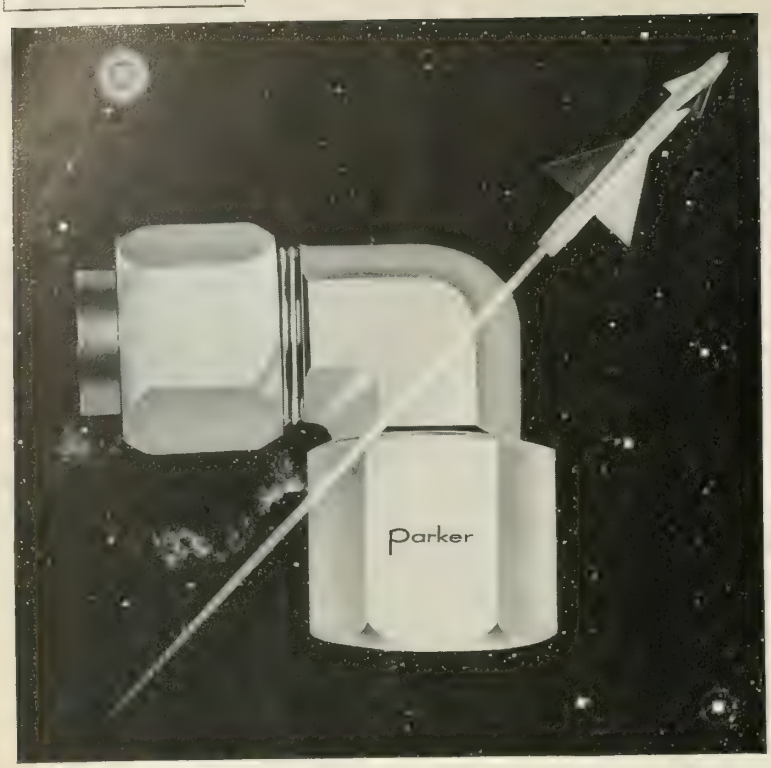
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"Liquid Oxygen" Replaces LOX Abbreviation in USAF

The Air Force is endeavoring to replace the abbreviation LOX with the words "liquid oxygen" where rocket fuels are concerned. The correction has been found necessary because of a conflict with the industrial designation LOX, which refers to liquid oxygen explosives.

The Air Force is undertaking the action to prevent dangerous and possibly disastrous results of the conflict. The term LOX will be deleted from all technical orders and directives, including reidentification of containers with the words spelled out, and the development of color coding for liquid oxygen containers, pipes and systems.

Thor-Jupiter Engine Now in Production

NEOSHO, Mo.—*Thor* engine production is underway at North American Aviation's $13.2-million Rocketdyne plant. The office and 228,000-square-foot facility was occupied in Feb. 1957. Ground on the 200-acre test site was broken a year ago and the large test stand is nearing completion and awaits its first firing.

Tests on the gas-generator units have already been made in the bank of special components test stands. LOX for the *Thor-Jupiter* engine will be trucked in from Tulsa, Okla.

The Neosho plant is located on 1785 acres of the northeast corner of Fort Crowder. The plant now employs about 720 workers with that figure expected to reach 800 by June of 1958. Despite the fact that start-up is just underway, things at Neosho have been described as quiet pending some sort of decision on the *Thor-Jupiter* IRBM.

Features of the plant include chemical milling facilities, a large center-of-thrust measuring jig, and water equipment for checking flow of plumbing, valves, and injectors.

The test facility was inherited from Aerojet, which designed it and had construction already underway when it was decided that North American was to operate the plant. Extensive earthworks are used to provide shelter for personnel and to ring the storage and test stand areas. The large vertical test stand uses a water-cooled steel flame-deflector. Work is nearing completion on the test stand and the instrumentation center is being fitted out with electronic recorders. First firing of the large stand is expected this fall and the first engine may be a hand model from Canoga Park, Calif., or the first prototype from Neosho.

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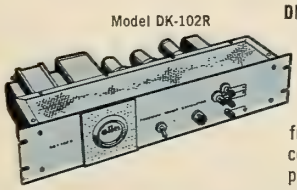
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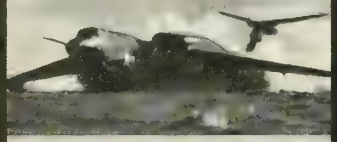
Special Products Division of International Electronic Research Corporation, Burbank, California

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The Navy's P6M Martin SeaMaster is a 600-mile-per-hour pioneer aircraft of tomorrow's mobile seaplane striking forces.

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Underground Missile Factory Delayed

HUNTSVILLE, Ala.—The problem of getting a firm contract from the Army or another branch of the service is delaying the start of a much-discussed but still secret project for construction of an underground missile factory beneath a mountain here near the Army Ballistic Missile Agency and the vast Redstone Arsenal.

It is the so-called "Green Mountain" project, reportedly involving the Army, American Machine & Foundry Co., and Chemstone Corp. Green Mountain is a big ridge, several miles long, in the Blue Ridge chain that extends all the way from Virginia to middle Alabama. Its southern slope runs down to the Tennessee River. It is located just across Highway 231 from Redstone Arsenal. The project was first reported in m/r in earlier issues this year.

Original plans, according to reliable sources here, called for the excavation of thousands of tons of limestone from the mountain's innards to create a vast underground factory which was to be operated by AMF, presumably in conjunction with Redstone Arsenal and ABMA. There were also reports that a "junior Pentagon" for missile defense would be part of the project.

The project involved some complex problems from the beginning. There was the matter of excavating the mountain, converting the limestone taken out into lime and other chemical materials, providing methods of processing and shipping it, plus the purchase of the necessary real estate at reasonable prices and political maneuvering for construction of docks on the Tennessee River by the Alabama Dock Commission.

The land was acquired through some 600 purchases engineered through the Huntsville Industrial Expansion Committee, a group of public-spirited citizens. AMF put up the required money for these transactions and at length acquired full title to the necessary acreage. The State docks were obtained and construction is currently under way.

In its early stages, the project was apparently delayed when Maj. Gen. John B. Medaris, commander of the Army Ballistic Missile Agency, reportedly urged that Madkin Mountain, a smaller ridge situated on the Redstone reservation, be used. This apparently was resolved, and the decision made to go ahead with Green Mountain.

Then the Chemstone Corp. of Cleveland, Ohio, entered the picture. There were negotiations over a period of months, and agreement was purportedly reached for them to supply the facilities for excavation and processing of the rock, using Silas-Mason-Hangar, excavators of Hudson River tunnels, as a subcontractor.

As of late spring, the project seemed assured. At that point, the Army and the Air Force became involved in the *Jupiter-Thor* argument from which stemmed the sensational court-martial of Col. John C. Nickerson, Jr., of ABMA. The Wilson memorandum, assigning operational control of all missiles of more than 200 miles range to the Air Force, had also raised questions about the project.

At this stage, AMF, which is heavily engaged in development and manufacture of guided missile support equipment, control systems, ballistics, auxiliary power supplies and radar antennas, is said to be asking that the Defense Department, the Army or the Air Force make a firm contract for work to be done in the Green Mountain installation. The local leaders who have spurred the project are said to be urging AMF to go ahead with the project, then get a contract. Somewhere between these two positions is the fact that increased land values have already given AMF a profit of as much as $750,000 on the acreage as it now is situated. Also, it is reported that Chemstone and Silas-Mason-Hangar have lost original interest, and that another deal may be made with Flintkote Corp.

A decision on the project may be one result of the settlement of the *Jupiter-Thor* argument.

One Killed, Four Injured In Explosion at RMI

An explosion at RMI's Lake Denmark, N. J. facility recently killed one person and injured six others during a routine operation in the test stand. No engines were being run at the time and material damage was slight.

Killed was Herbert L. Bell, a representative of Chance Vought Aircraft. Most of the injuries were caused by flying metal and spraying propellant. An investigation is underway to determine the cause of the accident.

The RMI personnel injured are William Dellecker, Hjalmar Lagerquist, and Elmer Baierl. Chance Vought representatives injured are Glenn Repp. R. L. Johnson and R. D. Tweedy.

Washington Trends

By Erik Bergaust



WASHINGTON EXPECTS HIGH-ENERGY FUELS WILL DOUBLE boron demand in the next ten years. More boron is underway from U.S. Borax and Chemical Corp. The ore in the 80-million ton-load averages about 25% B_2O_3. Tailings could also yield lithium chemicals. Estimates of USB boron production is about 1-million tons per year. USB had been thinking of a "joint venture"—supposedly with Olin Mathieson—for boron research and production. Recently the boron firm announced that negotiations had broken off "by mutual consent."

PENTAGON IS TALKING ABOUT GOLD-PLATED REACTION ENGINES! Turbojets and possibly ramjets will get North American Aviation's "reflective coatings." Gold coats—thicknesses of 1/100,000 to 25/1,000,000 inch—are being sprayed on engine shrouds or on ceramic parts. The gold coating on the inside protects the engine from corrosion and heat. Rocketry went through this fad some years ago when it was fashionable to have the nozzle plated with gold, chromium, nickel, etc.

SENATOR STUART SYMINGTON (D-MO.) RECENTLY DECLARED Russia is "well ahead" of the U.S. in ICBM development and repeated charges that the Administration has cut back the ICBM program because of economy considerations. An effective anti-missile to ward off ICBMs is "at least ten years away," he said. "The idea that the anti-missile is around the corner, or only five years away, is absolutely false."

YOU ALSO HEAR PENTAGON OFFICIALS DISCUSS infrared counter measures: IRCM system that uses small heat-emitting rockets which can be launched from evading aircraft. Instead of a warhead, the IRCM rocket carries a flare or pyrotechnic (such as thermit) used in current *Sidewinder* tests. The attacking IR rocket will invariably (and wrongly) follow the smaller and higher-temperature flare. Meanwhile, solution-transistors may open an entirely new field in missile guidance. One expert visualizes a chemical system that can adjust to its environment (such as magnetic field, etc.), without outside help. Such systems could operate at high temperature without counter-measure-vulnerable electronics.

A SMALL BUT PROGRESSIVE FIRM ACROSS THE POTOMAC, Atlantic Research, put out a commercial solid-propellant strand burner some time ago. Recently a miniature mixer—for mixing small batches of new solid-propellant formulations—was introduced. Now Atlantic Research has come out with a small, commercial rocket motor. Its name is PET (Propulsion, Experimental Test) and it is being advocated for such sundry purposes as: testing small rockets, spinning larger rockets, acceleration of small masses, subjecting test materials to blast. PET delivers 40 lb. of thrust for one second from 0.213 lb. of "Arcite" composite propellant. It can be stored for 3 years. Ignition is achieved in a matter of milliseconds with a 6-volt dry cell.

GOVERNMENT OFFICIALS HAVE NO COMMENTS about recently reported atomic-rocket work in this country. A German newspaper recently claimed the U.S. is building atomic rockets. The German paper said Rocketdyne was building an atomic-powered missile which may well relegate Russian missiles to the scrap heap "in a very short time." Study contracts on atomic rockets have been let in this country, but we know of no atomic-powered missile in the prototype stage.

WASHINGTON'S NAVY MISSILEERS ARE ALL SMILES since the first *Polaris* test vehicle was successfully fired recently. Naval officials are understood to be working on a stepped-up schedule for atomic-powered subs for the *Polaris* (and for other possible FBMs expected to follow). Big problem is to synchronize missile and sub production so that the two weapons elements will be ready for each other in shortest possible time.



Circle No. 37 on Subscriber Service Card.

First Steps Taken to Form Missile Association

First steps have been taken to form a missile industries trade association. The first formative meeting was held September 23 in the Virginia Room of the Mayflower Hotel in Washington, D. C. A second is scheduled for October 22. It is expected that with this second meeting a trade association charter will be approved for incorporation.

Originally proposed as the National Industry Conference, NMIC, the organization's name has been changed to Associated Missiles and Rockets Industries, AMRI. Its basic purpose is to represent the interests of rockets, missiles, and space flight industries as a definitive group, including major prime systems contractors, major subsystems contractors and the various important subcontracting and components companies. A concerted effort is being made to bring together a representative cross-section for the October 22 meeting.

The September 23 meeting was attended by some 60 representatives (from about 30 companies) of industry and government. Companies present included: Northrop Aircraft, Inc., Cessna Aircraft Co., Raytheon Manufacturing Co., Aerojet-General Corp., Westinghouse Electric Corp., Ford Instrument Division of Sperry Rand, Thiokol Chemical Corp., Kaiser Industries, Harvey Industries, Haveg Industries, Inc., RCA, Atlantic Research Corp., Cook Development Corp., Aeronutronics Systems, Inc. (Ford Motor Co. subsidary), Cook Electric Co., and others.

The meeting was addressed by representatives from Army, Navy and Air Force concerned with missile budget, mobilization and production planning, who supported the need for such an organization. Attending as individuals were Vice Adm. Charles B. Momsen, USN (ret.), and Col. William O. Davis of the Air Force Office of Scientific Research. Both indicated they thought such an organization would provide a useful service to the missile industry.

Chairing the meeting was Kendall K. Hoyt, an old-time Washington, D. C. aviation consultant and former general manager of the National Aeronautic Association. He is acting as secretary of the proposed missile association.

A certificate of incorporation and a set of by-laws were presented to the September 23 meeting as working papers and as a means of indicating the nature and scope of the proposed organization. These working papers were drawn up free of charge by Andrew G. Haley, who personally feels that the organization should come into existence as long as it will not duplicate the services of the American Rocket Society, the Institute of Aeronautical Sciences and the Aircraft Industries Association.

The question was asked at the meeting: Who is behind this organization? No detailed answer to this was forthcoming. However, investigation reveals that the movement has been largely spontaneous, indicating a widespread feeling for the need of such an organization. From the way that the meeting proceeded, however, it seems fairly obvious that Diversey Engineering Co. is among the association's most enthusiastic supporters. Reports that an editor of Missiles & Rockets magazine agreed to act as a central contact point in the beginning are true. However, American Aviation Publications Inc.—m/r's publisher—points out that this was without authorization or knowledge of the company and that since before the September 23 meeting, no member of m/r's staff has participated in the promotion of the association.



The men who will decide whether it will be JUPITER or THOR—the Committee on Missile Study: Left to right—Maj. Gen. Medaris, William H. Holaday, and Maj. Gen. Schriever.

Red Satellite to Transmit On 40 Megacycles

The IGY satellite to be launched by the USSR will transmit on 40 mc instead of the 108 mc used by the *Vanguard* Satellite. It had been anticipated that the Soviet satellite's instrumentation would be compatible with the minitrack system but it now appears that tracking the Soviet sphere with western equipment will be impractical.

A description of Russia's satellite launching vehicle and launching program was cancelled because no member of their delegation was qualified to discuss the topic, the Reds said.

Methuselah's Speed Scorches Its Paint

Lockheed has announced that its X-7 ramjet missile, dubbed *Methuselah,* has been tested over Alamagordo and its speed was such that the missile's paint was scorched. *Methuselah,* a test vehicle for the *Bomarc* ramjet engine manufactured by Marquardt, was recovered intact by parachute. A solid-propellant rocket engine boosts the missile to speeds suitable for ramjet operation.

NACA Declassifies Exotic Rocket

CLEVELAND, Ohio—NACA has just declassified its exotic propellant work which was published in 1949. The work was done here at the Lewis Flight Propulsion Laboratory with liquid diborane and LOX in a 100-lb. thrust rocket engine.

Several runs were made in an uncooled motor (L*=325 in). Runs of about 6 seconds were made. In the runs, maximum specific impulse resulted at about 35% diborane and 65% LOX, and gave uncorrected values of about 249 lb-sec/lb. Corrected for heat rejection gave 274 sec. This latter value is about 92% theoretical (299 sec).

The fuel was 95% diborane and 5% ethane and ethyl ether. This mixture was estimated to give a performance some 2% lower than for pure diborane. Extensive solid deposit build-up was found in the chamber. Deposits were about 1/32 inch thick, crusty in nature with a smooth dark gray or brown glazed surface. NACA did not say what the deposits were but educated guesses are that it is probably boric oxide slag.

Because of the high heat releases, there were severe burnouts—especially in the nozzle and injector sections. Diborane proved remarkably stable when subjected to heat and shock tests. The boron compound could not be exploded or detonated. The boron work was carried out early in 1948 and probably started the ball rolling on carrying out more work with the boron fuels. Experimental details of the diborane-LOX rocket tests are reported in RM No. E9C11 and are available from NACA in Washington.

Dust May Affect ICBM Behavior

Experiments by Cornell Aeronautical Laboratory, Inc. have suggested that small amounts of dust in the atmosphere may markedly affect behavior of a missile such as the ICBM in re-entry from outer space.

CAL made the observation during research in its hypersonic shock tunnels, which operate at speeds as high as 15 times sound.

Engineers at the laboratory observed that during some tests, small particles of dust in the air were accelerated to high speeds and upon striking a blunt-nose model reflected from the surface back into the air stream.

Photographs were taken in CAL's hypersonic tunnels and showed that the wake of the reflected particles created a pointed cone in the air ahead of the model. Although it collapses almost immediately, this cone intersects and disrupts the shock wave that normally builds up in the air around the model's nose.

Such disturbances in the air flow may markedly affect aerodynamic behavior and, if small traces of dust existed in the atmosphere, could conceivably influence the flight of a high speed missile during re-entry from outer space. Such a condition might also affect the transfer of heat, a critical problem of re-entry.

The laboratory revealed these findings recently in a technical paper delivered at a meeting of the Advisory Group for Aeronautical Research and Development of the NATO nations, held in the Netherlands.

New Red Observatory

The Leningrad branch of the Institute of Earth Magnetism, Ionosphere, and Radio-Waves has revealed the opening of a newly built magnetic-variation observatory. The installation is located on the western shore of Lake Ladoga, "in an area remote from industrial establishments and transport, which precludes interference with observations."



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BURROUGHS ALWAYS NEEDS *Good* ENGINEERS

Man ... the First Computer



HE CANNOT DUPLICATE HIMSELF . . . BUT MAN HAS CREATED A FANTASTIC SERVANT . . .

In a day when fascinating new computing concepts have swept scientific thought past all known barriers, it is easy to forget that behind all this amazing progress lies the one essential element for its success — MAN.

Although he creates computers and electronic brains that numb the imagination, the thinking man knows he is the first, and the most indispensable, of all computers. His genius at enslaving machinery to work with speed and accuracy surpassing his own is shown by today's electronic computers, which save man eons of time in solving problems recently considered hopelessly complex.

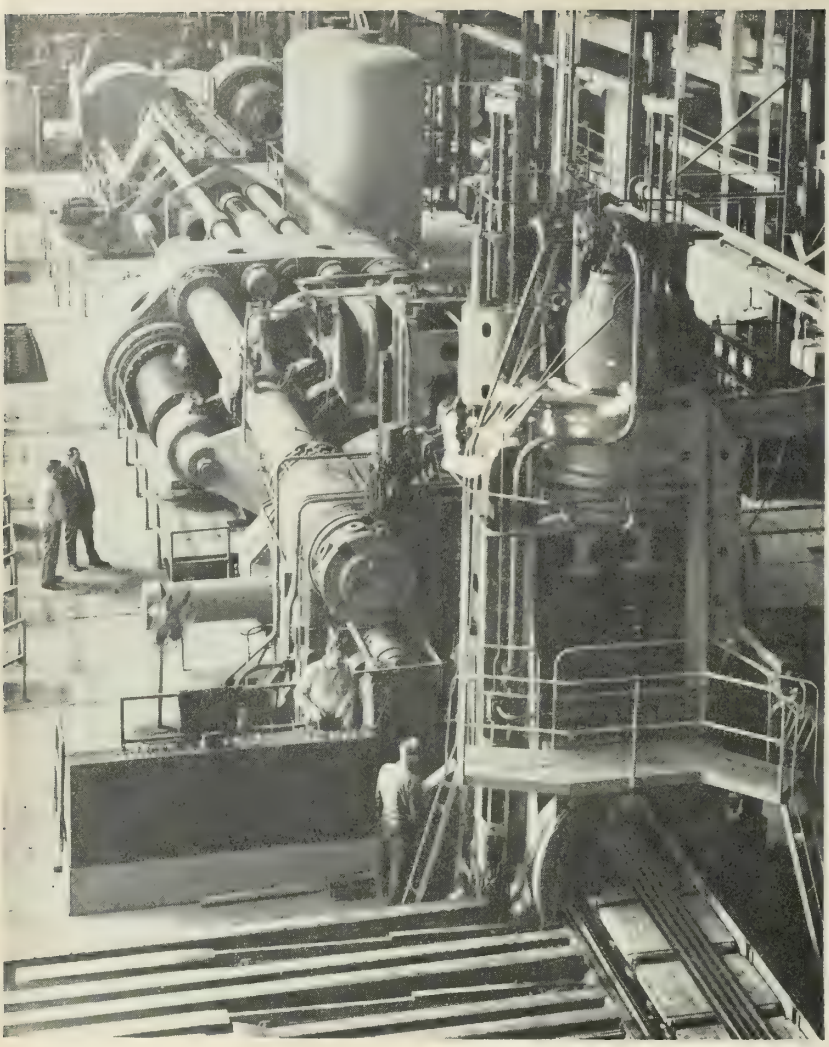
Solving many of these problems has enabled man to plan further accomplishments for his new electronic servant. In the future this remarkable assistant will handle languages as well as numbers; it will be capable of diagnosing and treating many illnesses; and, in industry, will actually "run" a plant. These are but a few instances of the computer's apparently limitless potential in a future restrained only by the boundaries of man's imagination.

Endowing computers with these near-human capacities is the special work of our talented creative teams at the Burroughs Research Center in Paoli, Pa. At this modern facility you can take part in our ambitious program, tackle new and refreshing assignments, guarantee your professional future and give your family the advantages of modern living in an established suburban community.

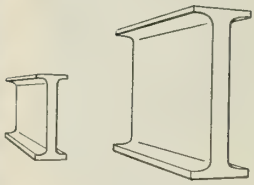
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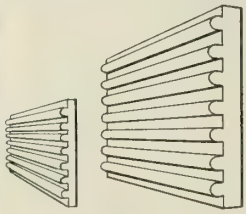


HOW THE 13,200-TON PRESS BOOSTS EXTRUSION CAPACITY



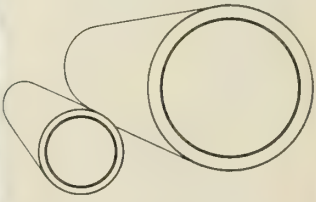
FROM 11″ TO 28″

STRUCTURAL SHAPES



FROM 9″ TO 20″

STIFFENED SECTIONS



FROM 10″ TO 24″ O. D.

TUBING

DOW'S NEW EXTRUSION PRESS PACKS 13,200-TON PUNCH

Here's a whole new range of large magnesium extrusions:
24-inch O. D. Tubing 28-inch I-Beams 80-foot-long sections

This mammoth press, newest addition to The Dow Chemical Company's rolling and extrusion mill at Madison, Illinois, is the world's largest magnesium extrusion facility. Its vastly increased capacities afford new opportunities for designers working with light metals. A wide variety of new magnesium applications for aircraft, missile, military and general industrial use are now possible and practical. In addition to extruding magnesium, the press is also available for large aluminum extrusions.

Here's how the big press will increase maximum dimensions of representative magnesium extrusions: Integrally stiffened sections, from 9 to 20 inches wide; I-Beams from 11 to 28 inches high; round tubing from 10 to 24 inches outside diameter; and maximum lengths of 80 feet. A large number of shapes and forms can be produced, limited only by the design of the die through which the metal is extruded. Many complex shapes that formerly required separate operations can now be formed in one operation.

If your design calls for large magnesium or aluminum extrusions, contact the nearest Dow Sales Office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Department MA 1406G.

YOU CAN DEPEND ON DOW

missiles and rockets

Circle No. 40 on Subscriber Service Card.

AF-Army-Ford Rocket Cracks Shell

In a dramatic demonstration of how much can be done for how little money when inter-service rivalries are set aside in favor of getting on with the job at hand, Air Force Office of Scientific Research's *Far Side* will soon streak to a record-breaking altitude of some 4000 miles.

Delayed by fringe weather conditions from typhoon Faye, AF is poised, ready and waiting to loose its giant helium-filled balloon into the stratosphere. Two hours later at 100,000 feet a 10-rocket, four-stage vehicle will blast loose. Within moments "up" will become "out," and man will crack the atmospheric shell that binds him to the egg called earth.

Carrying an instrumental payload weighing three-and-a-half pounds, this shot is the first of six planned in the current *Far Side* series. The basic configuration, however, with but slight modification is capable of landing dye-markers, flares or other payloads on the moon.

The prime contractor on the project is Aeronutronics Systems, Inc., a Ford Motor Co. subsidiary. The vehicle uses five Thiokol Chemical Co. *Recruit* and five Grand Central Rocket Co. *Arrow II* (developed *Loki*) rockets, all developed with Army Funds. The original proposal was made by Dr. S. Fred Singer of the University of Maryland's Physics Department. Dr. Singer is also supplying some of the instrumentation.

During September it looked as though the project might have to be dropped due to nondiscriminatory across-the-board slashes in allowable expenditures for the first six months of fiscal 1958. AFOSR's budget, however, has been completely reinstated.

One of the most dramatic aspects of *Far Side* is the amount of research gained for the dollars expended. AFOSR has put approximately $800,000 into *Far Side*. Aeronautics has added about $400,000 of its own funds.

While the firing is largely non-directional—aimed straight up—the vehicle spends a considerable time above the earth's atmosphere, taking something over two hours to make the complete "out-in" circuit. During all this time sensing elements are measuring space conditions which are telemetered back to earth.

Rocketeer Blackmon Does it Anyway

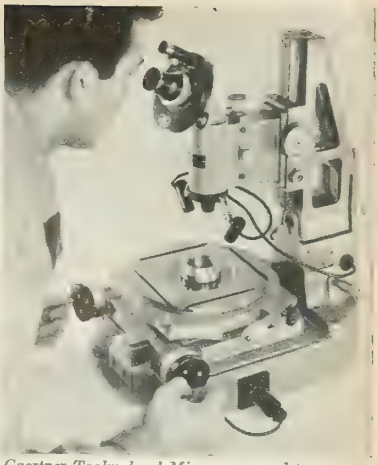
Unencumbered by interservice rivalries, budget limitations and the engineering shortage, Rocketeer Jimmy Blackmon fired his second rocket last month.

The eighteen-year-old rocket expert, whose first rocket never got off the ground due to extra-heavy governmental red tape and too much backpressure, took his second model to a deserted North Carolina beach and launched it with the aid of some friends. He didn't make the mistake of asking the government for clearance this time.

Using a propellant of powder zinc and sulphur, ignited by an automobile battery, the 5½-foot-long vehicle zoomed to 4000 feet at great speed and then fell into the ocean about 400 feet from the launching site.



Unimpressive beginning for a very dramatic event. Thiokol RECRUIT rockets are loaded aboard a DC-7 for shipment to Eniwetok Atoll in the Marshall Islands where they will be staged as FAR SIDE vehicles. Six launchings will be made before first phase of the program is completed. Aeronutronics Systems, Inc., and AFOSR are conducting the tests.



Gaertner Toolmakers' Microscope used to measure typical piece part. Co-ordinate range 4" x 2".

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Gaertner Toolmakers' Microscope

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The Gaertner Toolmakers' Microscope has been proven in use by U. S. Government Gage Laboratories, and by prime contractors and their subcontractors. With all parties using the same measuring instrument, inspection procedures are co-ordinated and disagreements and rejects minimized.

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Write for Bulletin 147-56

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Circle No. 41 on Subscriber Service Card.

Where Miles are Measured in Thousandths of an Inch

As ballistic missiles go farther and faster, weight becomes an increasingly critical problem. Walls of rocket cases, for example, must be still stronger to withstand higher pressures, yet still thinner to cut "hardware" poundage to a minimum.

Obtaining optimum wall thinness throughout in rockets now being developed is one of M. W. Kellogg's current defense assignments. It is a complex engineering task and demands a highly specialized knowledge of metallurgy, metal fatigue, heat transfer, corrosion, weight-strength relationships, and welding techniques.

The M. W. Kellogg Company has been closely associated with the development and fabrication of rocket cases and components since 1947. Inquiries are invited from organizations wishing to put Kellogg's specialized background to work on specific problems.



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Circle No. 42 on Subscriber Service Card.

Nike-Hercules Missile Nears Operational Status

FORT TOTTEN, N. Y.—The Army proudly displayed the *Nike-Hercules*, its latest addition to the Continental Air Defense system, during the most complete rundown to date of the Army's role in air defense.

An improved member of the *Nike* family, *Nike-Hercules,* originally designated *Nike B,* is currently undergoing final tests. It is expected to be integrated into existing *Nike* batteries as a supplement to the *Nike-Ajax* within the next year.

Nike-Hercules was reported to have a range more than twice the *Ajax*—approximately 70-75 miles—and 25 per cent higher altitude capability. Its greater velocity and the increased lethality of its atomic warhead will make it one of the nation's most deadly surface-to-air missiles.

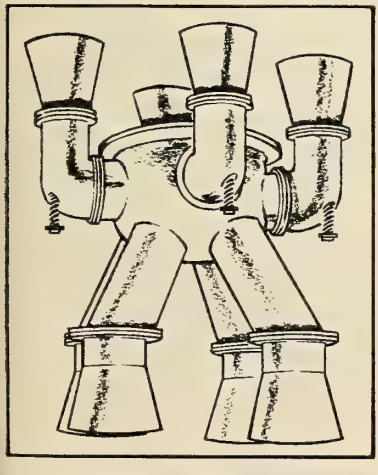
The five-ton, 39-foot missile has solid-propellant boosters and sustainer. Booster is a cluster of four *Ajax* while sustainer is a radical development in solid-propellant motors (see Industry Spotlight p. 145).

The sustainer motor is unique in that the exhaust nozzle is located at the end of a long constant-diameter tube extending from the combustion chamber. This design was motivated by the need to shift the center of gravity of the *Hercules* forward. Pitch, yaw and roll control system is located around the exhaust tube. A single solid-booster motor is currently under development. This will increase the mass ratio and specific impulse of the present four-barreled system.

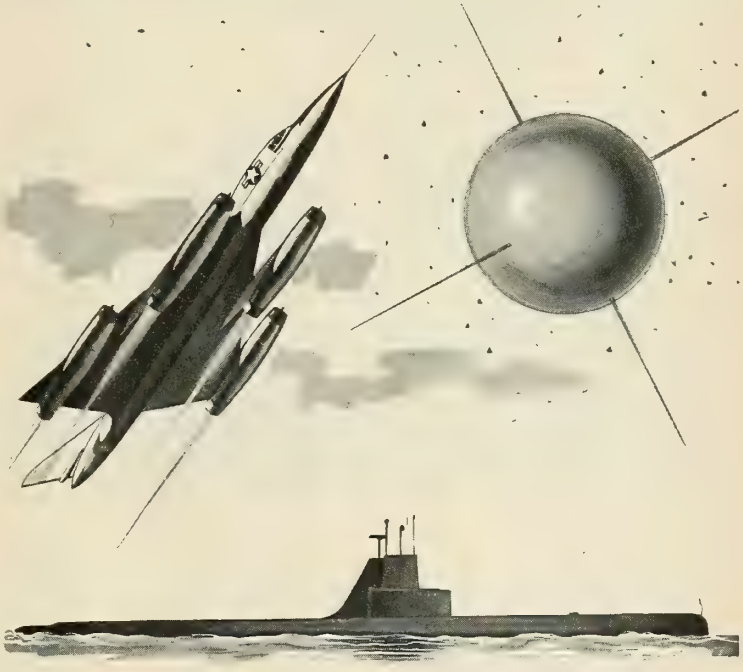
Present defense cutbacks will not slow down the *Hercules* program. Modification of existing sites will be needed before the *Nike-Hercules* can be integrated. Exact modification costs were not known although partial figures indicate costs will be high. Modifications, including new launchers and assembly buildings, will be approximately $40,000 for each site. In addition, a new universal fire control console costing one-half-million dollars will be needed. *Ajax* consoles will be modified.

Army officials announced that present *Nike-Hercules* models cost approximately $15,000, while each mission with an atomic warhead could cost up to $1 million.

Next addition to the family will be the *Nike-Zeus.* Two models are under development: an anti-missile missile and an intermediate range version. The Army, restricted to point defense, might infringe upon the area defense mission.



This plenum chamber with eight nozzles shows how some of the solid-propellant thinking is going at Thiokol Chemical Co. Four reversing nozzles could be used for either pitch and yaw control, clean separation or both.



We may have already solved your flexible ducting problem

Flexible's been solving tough ducting problems in many different fields for a great many years. And has engineered all kinds of special shapes and tubings in a wide variety of fabrics and coatings for unusual applications . . . a starter duct for jet aircraft, for example, as well as special ductings used in the missile field for ground support. So it could be that we already have the answer to your particular problem. If not, we'll put our research facilities, including our brand-new laboratory, to work immediately. If silicone ducting is called for, our special Silicone Department, working with automated machinery, is prepared to meet your specifications.

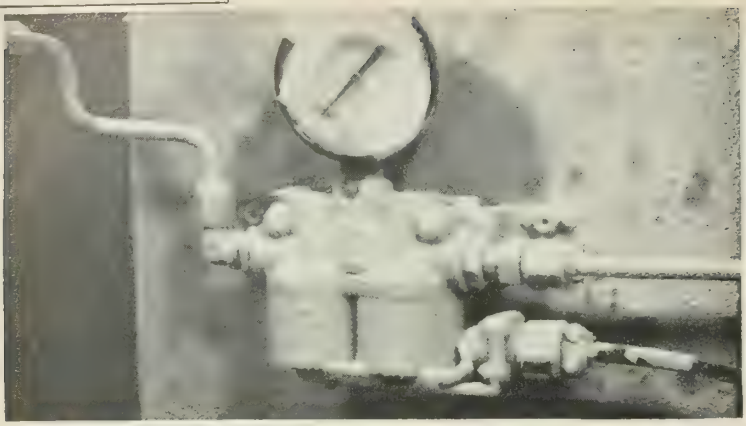
To find out how Flexible can solve your ducting problems, write us, outlining your requirements. Our engineers will be glad to put their experience to work for you. Write to Dept. 210.

Flexible Tubing

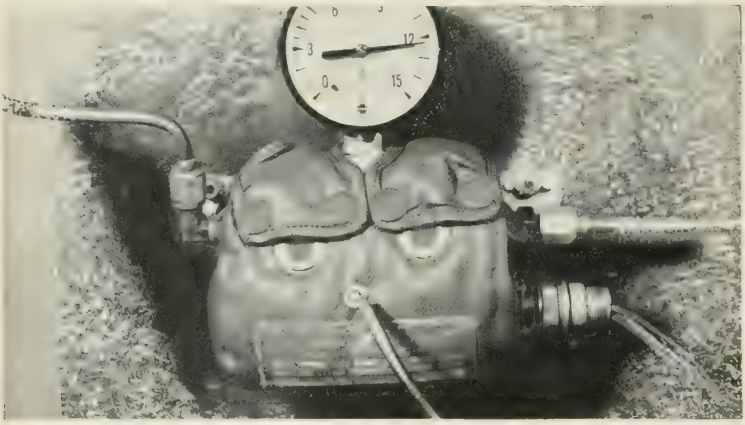
CORPORATION

Guilford, Connecticut • Los Angeles 64, California

Circle No. 43 on Subscriber Service Card.



FREEZE-UP of solenoid-controlled valve in airborne system at −65°F can choke off vital air supply. Manufacturer faces tight contract delivery schedule.



SPECIAL HEATING unit custom-designed and delivered by G.E. in 5 days enables stock valve to function properly, saves customer time, money.

AIR VALVE OPERATING AT −65°F SHOWS HOW . . .

General Electric Specialty Heating Maintains Component Temperature

When components must be kept at operating temperature, G-E specialty heating equipment does the job! Thermal conditioning applications ranging from hydraulic and electronic components to tiny test instruments have all been solved by experienced G-E heating engineers.

LET US ANALYZE YOUR HEATING PROBLEM. Whether it's fast delivery on a prototype or quantity production, General Electric can provide specialty heating products engineered to your specific component needs.

FOR MORE INFORMATION contact your local General Electric Apparatus Sales Office or send coupon.

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Section K220-12, Schenectady 5, N. Y.

Please send bulletin GEA-6285A, G-E Specialty Heating Equipment

.....**for immediate project**
.....**for reference only**

Name.....

Position.....

Company.....

City..... **State**.....

Progress Is Our Most Important Product

GENERAL ELECTRIC

Explosion Waves Studied

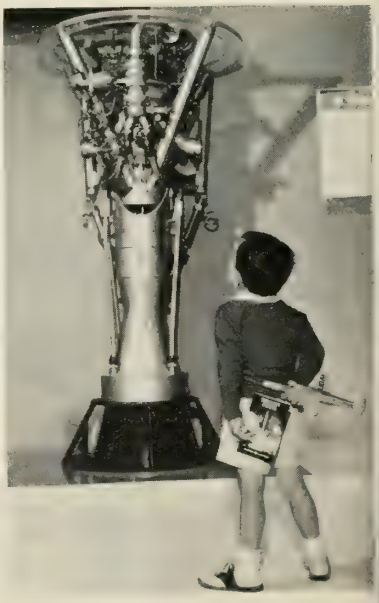
The Air Force is using high-speed photography in attempts to tame explosions and put them to use for propulsion. The ARDC hopes to learn enough about the detonation waves to suggest ways to control them. The research could conceivably lead to the development of smaller and lighter engines.

In order to photograph the waves for study, the AF is utilizing a Beckman & Whitley ultra-speed framing camera that shoots 25 individual photographs in 1/15,000th of a second as the waves pass an eight-inch window in the 25-foot test chamber.

Deserves a Silly Answer*

Seeking reasons for the presence of Dr. Ramo, America's "top guided-missile man" in this country, the News Chronicle diarist got a "Don't know" from the Ministry of Defence, a "Here on pleasure" from the U.S. Embassy and a "Strictly business" from the visitor himself, while British guided weapons spokesmen countered with "Who is Dr. Ramo?" and "How do you spell it?" and the diarist had to end a promising paragraph with, "Maybe he is just admiring the beauties of nature." This had all the others wishing they'd thought of that one at the time.

**Reprinted with permission of PUNCH.*



Five-year-old John Kirby, gazes at the General Electric X-405 rocket engine, which will provide the thrust for the first stage of the three-stage earth satellite projectile.

Flexon®

ducting and components

engineering and design briefs

Afterburner Cooling Assembly Gangs Straight Wall Tubing For High Strength, Light Weight

A minimum weight plus complex fabricating problems were critical factors in the development of this afterburner cooling blast tube assembly.

The space envelope was shallow and wide and over six feet long. The assembly was required to be tested at 28 psig with collapsing pressure of −2.5 psig and at a temperature of 250° F.

Flexonics answered the need by



End view of afterburner cooling assembly. Note rectangular shape of ends.

forming standard High Strength welded tubing into a gang. Ends of the tubes were formed to a rectangular shape to adapt them to the required end fittings. The tubes are held together with welded bands as the illustration of the unit shows. Tabs are provided for mounting in the airframe.

Tubing used in the assembly is 1.625″ O.D. by .011″ wall thickness. Type 321 High Strength stainless steel is used, with ultimate of 100,000 psi.

Facilities are the Key Factor

In the engineering, fabrication and proving of assemblies such as this, facilities are all important. As the pioneer and leading manufacturer of light weight corrosion resistant flexible assemblies and ducting, Flexonics Corporation has facilities second to none.

The engineering skill of Flexonics Corporation is proved by the scores of developments already made ranging from single flex connectors to entire aircraft ducting systems.

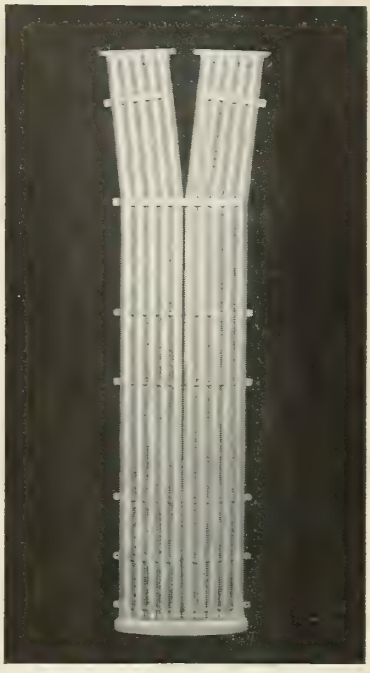
The manufacturing know-how of Flexonics Corporation is proved by the daily trouble free production of intricate assemblies and by such developments as the re-deposition process of forming ducting components.

The ability to prove assemblies before their installation in aircraft and engines is assured by the extensive Flexonics laboratories capable of the most advanced testing procedures.

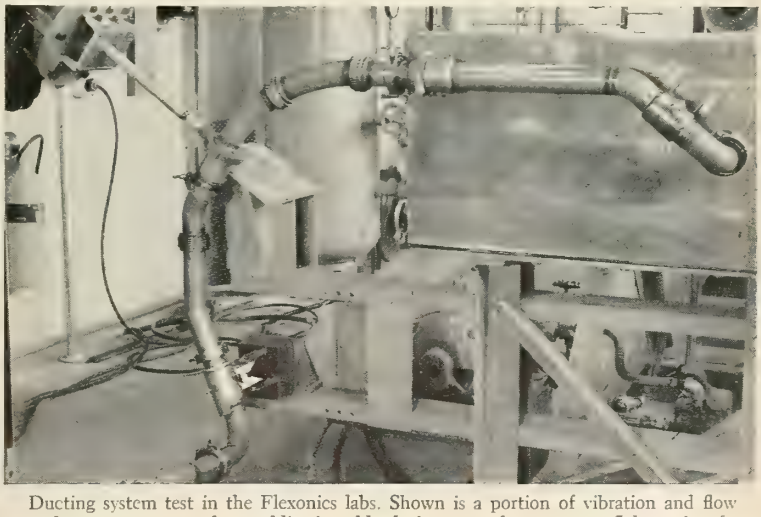
Engineering Assistance

Whenever you have a problem involving aircraft plumbing, take advantage of the know-how and facilities of Flexonics Corporation. For specific recommendations send an outline of your requirements.

For help right at your desk, write for information on how qualified persons can secure copies of the new Flexonics Engineering Manual.



Complete afterburner cooling assembly. Note use of straps to gang the tubing.



Ducting system test in the Flexonics labs. Shown is a portion of vibration and flow under pressure tests of assemblies in a bleed air system for a current fighter aircraft.

NOW, FROM FLEXONICS A COMPLETE LINE OF FLEXIBLE CONNECTORS AND DUCTING

With the acquisition of FLEX-O-TUBE Division, Flexonics Corporation is now able to offer a complete line of rubber, synthetic and Teflon hose assemblies and crimped-on and re-usable fittings. Write for full information.

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A-34

Circle No. 32 on Subscriber Service Card.



Behind the Curtain

by Dr. Albert Parry

Moscow's announcement of the first successful Soviet ICBM test was clearly meant as a threat to us. Do the Soviets know that the threat will only spur us on with our ICBM work? They do. They must feel they have no choice but to brag and threaten. And not only for foreign policy reasons (to queer the disarmament talks; to stop us from doing something about the Syrian mess; to intimidate the UN in the Hungarian debate), but also because of their domestic unrest—particularly the Soviet and satellite youth. Nikita may be saying to his Kremlin colleagues: "Let's make our youths forget their restless cynicism by a bit of ICBM-rattling. Let's make them patriotic and proud about Communism again by telling them we are ahead of America in the ultimate weapon."

•

Russia does not yet have a model of her artificial satellite. Her scientists haven't as yet decided on the size and weight of those Red moons. So said Dr. Valeria Troitskaya, general secretary of the Soviet IGY Committee, on her visit to Toronto. Russia does not yet have rockets ready to launch artificial satellites, declared Dr. Vladimir Kotelnikov while heading a 16-man Soviet delegation to San Francisco's Western Electronics Show and Convention. And this man ought to know. He is chief of the Radio and Electronics Division of the Soviet Academy of Sciences.

Yet, from Leningrad, comes the contradictory news that the Main Astronomical Observatory of the same Academy has begun its final intensive preparations to watch the Soviet satellites once they are launched: 30 special "spyglasses" are being installed on as many platforms at Pulkovo, and teams of observers are being formed under the command of D. Shchegolev, described as "candidate of physico-mathematical sciences." This may suggest that, Drs. Troitskaya and Kotelnikov to the contrary notwithstanding, the Red moment of launching is near.

•

Soviet scientists have lately shown a marked interest in whatever U.S. and West European reports they can find on American research experiments with "weightless airplanes." In the Moscow KOMSOMOLSKAYA PRAVDA young Russian physicist P. Nikitin quotes a West German aviation magazine to the effect that eight commercial American concerns and seven American universities and technical colleges are working on the problem of gravitation and how to defy it by building and flying "nonweight aircraft." According to Nikitin, anti-gravitation forces once invoked "will be sufficient even for interplanetary flying apparatuses." The Soviet scientist calls special attention to "a news item published in AMERICAN AVIATION saying that Avro, a Canadian firm, has begun the construction of a flying disc which will rise vertically" as proof that gravity-defying flights may soon be possible.

•

The 1957 program of the Soviet State "Foreign Literature" Publishing House includes publication of a book entitled EXPLORATION OF THE UPPER ATMOSPHERE BY ROCKETS, a Russian translation, apparently, from English.

Long Range Planning and Research at Marquardt...



by
Roy E. Marquardt
President

Although ramjet development in the Powerplants Division is the major activity here at Marquardt, there are three other divisions carrying on significant work; Controls and Accessories, Test, and Long Range Planning and Research.

The youngest of these Divisions is Long Range Planning and Research. Headed by John Drake, and numbering 50 engineers, the Division has two primary functions:

PLANNING — anticipating product trends in areas where we now operate or might enter. Actually this planning is done in a staff capacity, and normally the results end up as recommendations.

SUPPORT — to the other divisions, by introducing product improvements which offer promise for the future. These improvements generally involve a small scale program to establish the idea as feasible. This research function also may be concerned with areas which do not fit into present Marquardt projects.

Long Range Planning and Research was begun in 1954. One of its first studies concerned areas where the ramjet can now be used or where it might be used in the foreseeable future. To date some exciting new powerplant cycles have been plotted. Some are variations of cycles now in existence, others are radically different.

Projects also have probed new "exotic" fuels, new types of diffusers, accessory systems, and controls. One phase of Aircraft Nuclear Propulsion is now being explored.

Ground was broken near Newhall, California recently for a research test center. This aerodynamic facility will have testing capabilities to Mach 14.5 as a wind tunnel and Mach 10 for free jet testing with excellent simulation of full scale flight conditions (Reynolds Number). In addition, it will permit simulation of combustion conditions to Mach 8 and altitudes above 150,000 feet.

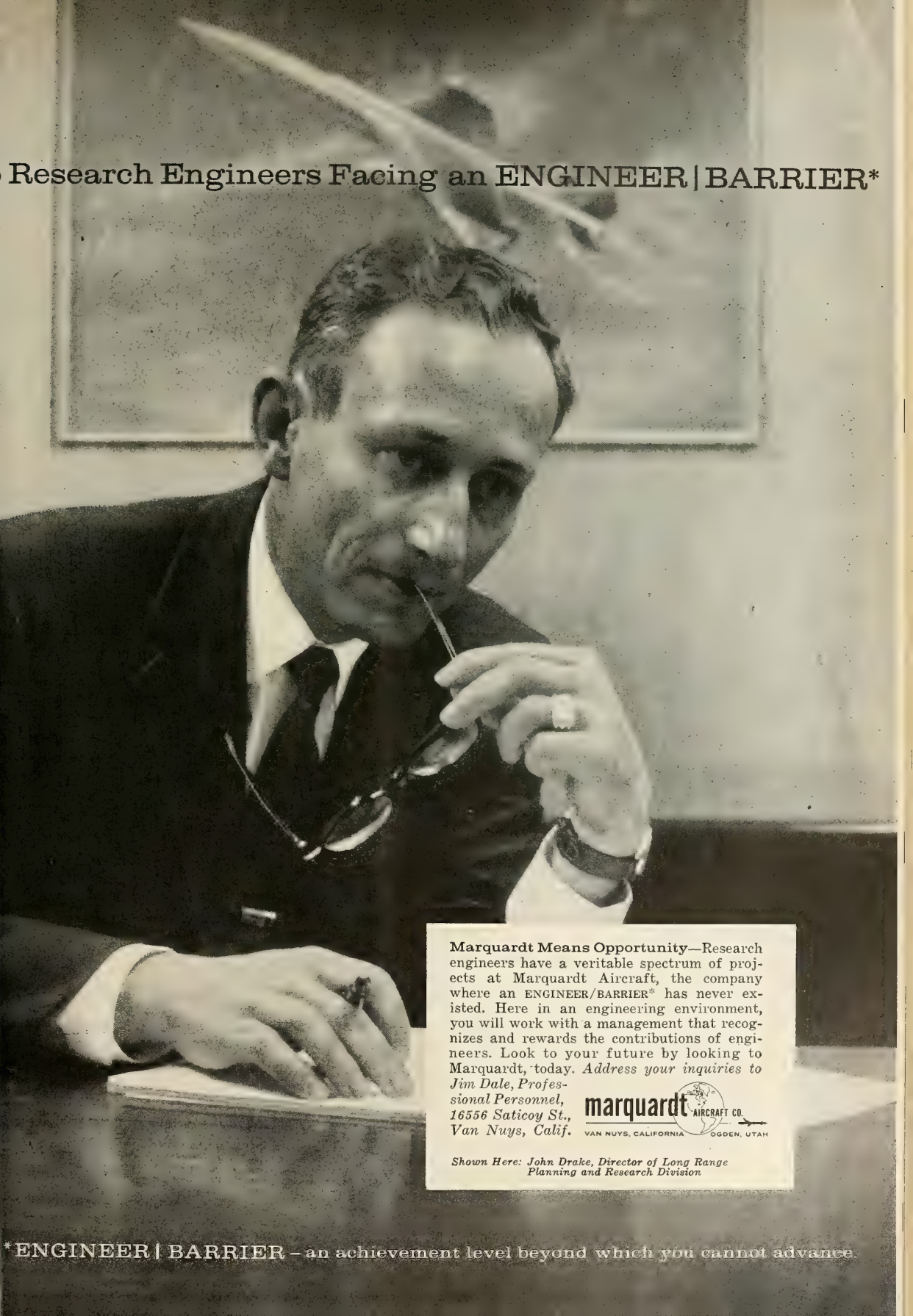
Within this Division, research engineers will find a spectrum of research engineering opportunities, including:

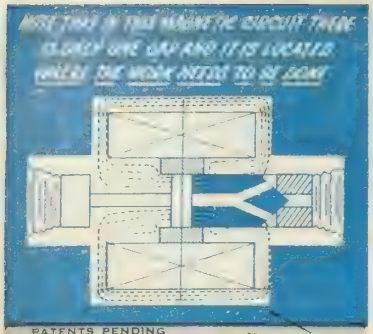
DESIGN	AERO-THERMODYNAMICS
NUCLEONICS	HEAT TRANSFER
CONTROLS	COMBUSTION

For information about these positions and the professional engineering environment at Marquardt, we invite you to write Jim Dale, Professional Personnel, today.

Roy E Marquardt

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FIRST IN RAMJETS


Research Engineers Facing an ENGINEER | BARRIER*
Marquardt Means Opportunity—Research engineers have a veritable spectrum of projects at Marquardt Aircraft, the company where an ENGINEER/BARRIER* has never existed. Here in an engineering environment, you will work with a management that recognizes and rewards the contributions of engineers. Look to your future by looking to Marquardt, today. Address your inquiries to Jim Dale, Professional Personnel, 16556 Saticoy St., Van Nuys, Calif.
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World Astronautics



By Frederick C. Durant III

The recent "first" issue of ASTRONAUTICS was labeled Vol. II, No. 1. Don't search for Vol. I; this designation refers to the series of ASTRONAUTICS published in the thirties, before the title was watered down to: JOURNAL OF THE AMERICAN ROCKET SOCIETY.

Incidentally, the appearance of ASTRONAUTICS has caused the folding of MISSILE AWAY! and AMERICAN ROCKET SOCIETY NEWS, two splendid publications put out by the N.M.-West Texas and So. Cal. Sections of the ARS. The edict originated topside in the ARS and was aimed at maintaining control over all advertising in ARS publications. Some bitter feeling developed in the conflict over rights of sections and the national headquarters of the ARS, but apparently all has been settled amicably. These section publications were a "labor of love" representing many thousands of hours of hard work in the interest of astronautics.

Finally, there are a welter of foreign space flight periodicals issued regularly. WELTRAUMFAHRT represents the German, Austrian and Swiss astronautical societies. RUMFART is published by the Danish Interplanetary Society. The Associazione Scienze Astronautiche (Torino) publishes ASTRONAUTICA, not to be confused with ASTRONAUTICA ACTA, the official organ of the International Astronautical Federation.

The Space Flight Committee of the ARS, under the leadership of Krafft Ehricke, is making remarkable progress in hammering out recommended technical programs for the future. Eleven subcommittees have been organized under the following headings: Space Flight Operations; Spacecraft Systems; Spacecraft Propulsion Physics; Astrionics; Spacecraft Equipment and Reliability; Space Flight Mechanics; Space Physics; Legal Aspects; Sociological Aspects; Training and Education; and Documentation.

Ehricke was successful in obtaining as chairmen for these subcommittees outstanding individuals who were not already members of the Space Flight Committee. Thus, the working strength of the SF Committee has been augmented by a dozen excellent men as chairmen, plus many more individuals selected to membership of the subcommittees. In addition to the activities of these subcommittees, the Space Flight Committee itself is working on a program of action to be presented to the ARS Board. In the past the annual business meeting of the ARS has been rather dull to most casual observers. But at the annual meeting in New York this December it is predicted that some mighty interesting projects and proposals will be forthcoming.

•

Switzerland is known to have two well-developed guided missiles: the Oerlikon-Contraves, Type 50 Series, surface to air missile and the Oerlikon-Contraves-Boelkow *Cobra* antitank weapon. The Swiss guided missile program like the country is small. But also like the country, the program is highly developed. The development costs of these missiles have been borne essentially by private industry. Sales have been made not only to the Swiss government but to a number of other nations, as well. The USAF evaluated 25 of the early Type 50 missiles at Holloman in 1954.

The arms division of Oerlikon is justifiably famous in the arms and munitions world. During World War II the Oerlikon 20 mm. antiaircraft gun was widely manufactured in the U.S. and Great Britain as well as by the Axis countries.



Painting by Chesley Bonestell from the book *The Conquest of Space*, by Willy Ley and Chesley Bonestell, published by the Viking Press ($4.95). © C.B.

How many Fenwal Controls aboard?

You might make a reservation for the first passenger trip to the moon now. But there are still some things to be determined.

We don't give you a list here of all the Fenwal temperature and control devices that may be found on board. But we do know that our past performance in solving the temperature problems on such a high proportion of modern aircraft will stand us in good stead on solving new problems. And, give manufacturers a good sense of security in adopting Fenwal devices.

For instance, in the field of fire and over-heat detection, Fenwal products are well advanced and proven in both unit and continuous types. Fenwal has the men, the equipment and the knowledge to insure fruitful exploration and practical, trustworthy products for today and tomorrow.

It will be encouraging to find, too, that your engineers will get along fine with Fenwal engineers. Our aircraft catalog on request. It's interesting. Fenwal Incorporated, Aviation Products Division, Ashland, Mass.

Fenwal

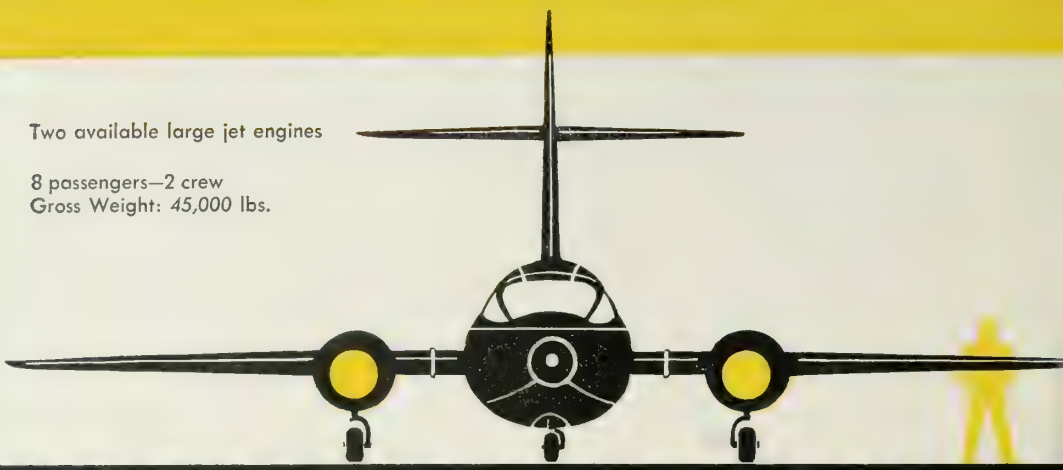
Controls Temperature . . . Precisely

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EXAMPLES OF SMALL JET ENGINE WEIGHT LIFTING
ADVANTAGES AND AIRFRAME SHRINKAGE . . . ON IDENTICAL MISSIONS.

Two available large jet engines

8 passengers—2 crew
Gross Weight: *45,000* lbs.



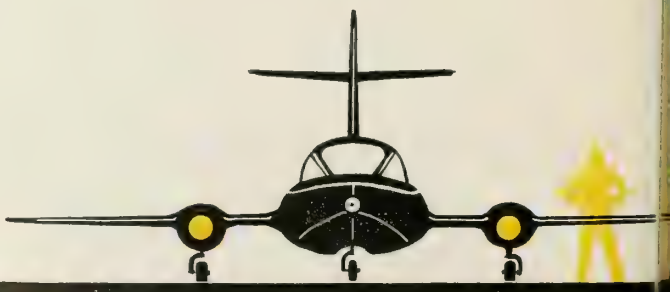
Four Small Jet Engines

8 passengers—2 crew
Gross Weight: *26,000* lbs.



Two Small Jet Engines

4 passengers—2 crew
Gross Weight: *16,000* lbs.



SMALL JET ENGINES...

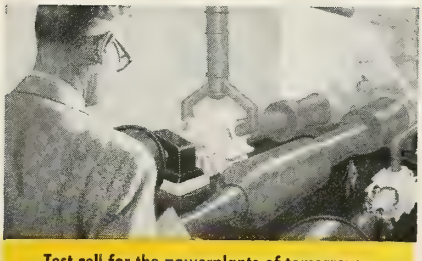
CHAMPION WEIGHT REDUCERS

The new breed of high-performance, lightweight, small jet engines coming to life will broaden the horizons of jet aircraft design, performance. versatility and utility.

Best of all, the new small jets will make possible lighter, less costly aircraft with performance to match the big planes of today. With power/weight ratios as high as 8 to 1 and long range potentials of more than 10 to 1, the small jets may power lightweight fighters, basic and advanced jet trainers, transports of half the size with proportionate savings in weight and cost. As the new airframes shrink, their performance and especially their versatility and utility expand.

Performance and potential in a smaller package . . . this is the promise held out by the new family of small jet engines of the J83 type now under development and test.

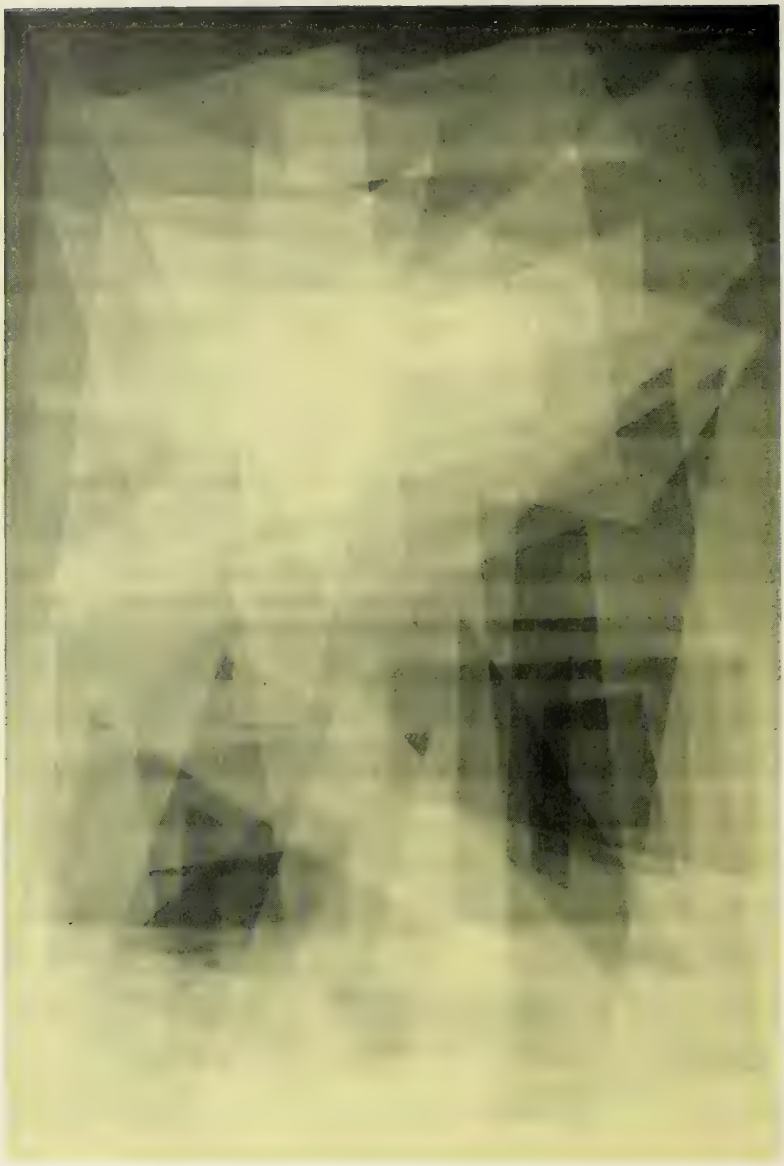
Fairchild Engine Division has long been a pioneer in aviation and a pioneer in power and is dedicated to the small jet engine concept.



Test cell for the powerplants of tomorrow—a vital link in the chain of advanced research program at Fairchild Engine Division. Equipment, experience and design ingenuity—these are the elements in Fairchild's pioneering in small jet powerplants.

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DEER PARK, LONG ISLAND, N. Y.
A DIVISION OF FAIRCHILD ENGINE AND AIRPLANE CORPORATION

WHERE THE FUTURE IS MEASURED IN LIGHT-YEARS!



"NIMBUS," a new painting by the well-known team of science-artists Simpson-Middleman. In this work, the creators have found new artistic meaning in the Moon and its reflected light. An attempt to capture the polarized nature of moonlight is made. The result, an almost half light. Collection of the Whitney Museum of American Art, New York.

Work in the world of supersonic flight—at Boeing

Supersonic flight is still in its infancy, and Boeing engineers are engaged in the adventurous task of pushing forward the frontiers of knowledge in this years-ahead world. Underway at Boeing are design projects for top-secret aircraft and missiles far more advanced than any yet developed. Related explorations delve into the required properties and capabilities of materials, fuels and systems not yet in existence. You'd find working on advanced Boeing projects a true adventure—challenging, rewarding, stature-building. Boeing offers this opportunity today to scientists, and to experienced engineers in many categories.

BOEING

Drop a note now, to John C. Sanders, Engineering Personnel Administrator, Boeing Airplane Company, Department R-68 Seattle 24, Washington.

VOL. 2 NO. 10
OCTOBER, 1957

missiles and rockets
MAGAZINE OF WORLD ASTRONAUTICS

m/r exclusive:

Report on Missiles and Rockets Around the Globe

WHAT WE BELIEVE to be the most extensive up-to-date roundup of guided missiles and rocketry around the globe is presented in this issue of m/r. With missiles and rockets manning an ever-increasing segment of our ramparts against aggression, it is important that we note all developments in this field—wherever these developments occur.

MISSILES AND ROCKETS has closely watched the international missile industry with as sharp an eye as it watches the American missile industry. Thanks to our world-wide editorial service, it has been possible for us to keep a sensitive hand on the pulse of the rocket and missile industry around the world.

What is the international missile industry? What is it doing? Who leads in production? Who leads in research?

MISSILES AND ROCKETS has obtained the answers to these questions by sifting hundreds of reports, its editors and contributors having traveled thousands of miles, reporting in many countries. The answers are here on the following pages.

There is not one overall leader of the globe's missile industries. In Europe, Britain leads in the production of guided weapons. France has leadership in the research and development fields. On the other hand, Japan may well lay claim to leadership by her sheer enthusiasm for the future of rocketry. These are leaders. The U.S. has no claim to leadership of all missiles and rockets everywhere. We are challenged by other missile and rocket makers. They are good.

So are the Soviets. In the announcement regarding the ICBM capabilities which they claimed, the Soviet Union said:

"The solution of the problem of designing (intercontinental) ballistic rockets will make it possible to reach remote areas without resorting to a strategic air force, which at the present time is vulnerable to up-to-date means of antiaircraft defense."

Many of the Soviet missiles are as effective as Western missiles, though the high polish may not be there in all instances. As in the case of any weapon, they can kill you just as dead as a "sophisticated" model.

The Soviet arsenal is bristling with weapons that will back up the ICBM: firings of the various IRBM models take place weekly, the Red Fleet uses Arctic waters as a proving ground and test range, and a large portion of the submarine fleet is being equipped for missile handling. These submarines with IRBMs can do what the ICBM is not yet ready to do.

When the Red Army took over the German rocket centers, they sent back everything they could get their hands on. From this data and material, the Russians constructed over 1000 V-2s to acquire production techniques and for training. The Soviet version, the T-1, had an improved engine and greater range. The next step was a two stage IRBM designated the T-2, and from this evolved the T-3 ICBM, the entire program probably resembling an erector set with one assembly being "stacked" upon another.

Hence the USSR, with perhaps the largest strategic air force in the world, rendered it obsolete as soon as the Soviet Army successfully fired one ICBM. Albeit this is propaganda to enhance the effect of the ICBM announcement, it is a sign. And you don't shoot down many missiles with airplanes—just other missiles.

Britain has staked her survival on the guided missile. Sweden will make no more manned interceptors. There are greater stakes on the table—or globe—than anyone would have wagered on missiles just a few short years ago. To protect themselves against loss of this stake, the countries reported on in this exclusive roundup are encouraging rapid expansion of their respective missile industries.

The editors and contributors who have assembled the information presented in m/r's roundup include: Seabrook Hull and Norman Baker, assistant editors; Frank G. McGuire, business news; Alfred J. Zaehringer, rocket engineering; Henry P. Steier, electronics.

Also Frederick C. Durant III, astronautics; Dr. Albert Parry, Soviet affairs; Raymond L. Garthoff, special contributor, former specialist on Soviet Military Affairs for the RAND Corp.; Frederick I. Ordway, Heyward E. Canney and Ronald M. Wakeford, research editors; Franco Fiorio, special contributor on Italian affairs; Anthony Vandyk, international editor; Jean-Marie Riche, Paris; James Hay Stevens, London.

The Editors



RUSSIA . . .

Leading the World in ICBM and Satellite Development?

By Dr. Raymond L. Garthoff

FOLLOWING A PERIOD of tight wartime censorship on any disclosure of the military uses of rockets, Soviet publications in the spring of 1944 began to print articles on long-range rockets. One of the first was an article in April 1944, by the eminent scientist, military technologist and publicist, Dr. G. I. Pokrovsky, Professor Major General of the Engineering Technical Service. Its title: "The Utilization of Long-Range Rockets." This article marked the first concrete evidence of the developing Soviet interest in long-range rockets.

Lt. Gen. M. Gerasimov, an important officer in the ground forces' training program, published an article in May 1946, in the official journal, THE MILITARY HERALD, in which he raised the problem of the influence of atomic weapons and other new military technological developments on the entire military training program. He predicted specifically that: "The significance of rocket artillery, which is difficult to detect but capable of firing projectiles with sufficient accuracy to destroy targets located hundreds *and possibly thousands of kilometers away,* will grow . . ."

In January 1947, another Soviet general, Lieut. Gen. of Artillery P. N. Kuleshov, in an article in FOR DEFENSE stated that: "A great future opens for rocket artillery, *especially for long-range artillery.*" He also spoke of "rocket artillery of *strategic significance* with a range of several hundred kilometers." Finally he cited an American report on German plans for a two-stage ballistic rocket capable of attacking the continental U.S.

A third article, by Maj. Gen. of Aviation E. Tatarchenko, appeared in the official Air Force journal, HERALD OF THE AIR FLEET, in May 1946. He also called attention to the German efforts to create a rocket missile capable of bombing New York.

He stated: "Although this attempt did not meet with success, the very fact that precisely this technical task was set as completely practicable is very important." In addition, he paraphrased a statement by Gen. Arnold to the effect that: In the future it is extremely likely that rockets will be capable of hitting any point on earth, within a two-and-one-half square kilometer target area.

The Soviets use the term "long-range rockets" in describing the V-2 and other ballistic rockets of a few hundred kilometer range. In the GREAT SOVIET ENCYCLOPEDIA (late 1955), German V-2 weapons of World War II with given range of "up to 300 kilometers" are described as "long-range rockets." Consequently, general Soviet statements on long-range rockets, such as by Marshal Zhukov, must be understood as describing weapons with a range of a few hundred to several thousand miles.

The first direct communist reference to intercontinental rocket weapons systems appeared in December 1953, in an East German radio commentary by the military analyst, Egbert von Frankenberg und Proschlitz. Frankenberg stated: "Soviet long-range bombers would reach all points in the operational rear and home zones of the enemy. *The guided twin rocket (sic) suitable for transatlantic delivery has been developed further.*" A few days later (Dec. 22, 1953) the Soviet Government declared in a formal statement that "there exist rocket weapons which contemporary technology permits to be employed at ranges of thousands of kilometers, without the use of aircraft . . ."

The ambiguity was doubtless intentional. In fact, subsequent early statements were still less specific. For example, an article by an anonymous retired general, which appeared in IZVESTIA in January 1954, stated: "The contemporary development of aviation, rocket weapons, and the submarine fleet makes it possible to deal crushing blows across a distance of many thousands of kilometers."

In an article in March 1955, Maj. Gen. Pokrovsky stated that "long-range rockets capable of flying over a thou-

The latest Red statement on long-range missiles was radio Moscow's announcement of the successful test of an Intercontinental Ballistic Missile which went, in part, as follows:

In conformity with the scientific research program, successful tests of an intercontinental ballistic rocket as well as explosions of nuclear and thermonuclear weapons have taken place in the Soviet Union.

A super-long-distance intercontinental multi-stage ballistic rocket was launched a few days ago. The tests of the rocket were successful. They fully confirmed the correctness of the calculations and the selected design.

The rocket flew at a very high, unprecedented altitude. Covering a huge distance in a brief time, the rocket landed in the target area. The results obtained show that it is possible to direct rockets into any part of the world.

The solution of the problem of designing intercontinental ballistic rockets will make it possible to reach remote areas without resorting to a strategic air force, which at the present time is vulnerable to up-to-date means of anti-aircraft defense . . . the Soviet Government express gratitude to a large group of workers who have taken part in designing and manufacturing the intercontinental ballistic rockets, and the complex of facilities for their launching.

A series of explosions of nuclear and thermonuclear (hydrogen) weapons has been staged in the USSR in recent days. In order to insure the safety of the population, the explosions were set off at a high altitude. The tests were successful.

Russian Intermediate-Range Missiles and Upper-Air Vehicles

	Model	Type	Length (ft)	Dia. (in)	Range (Mi)	Status	Notes
Missiles	T-5	BR				P;O	Artillery & antitank. Composite solid propellant rocket.
	ME	G	1.5-2	3.35	1-2	P;O	Recoilless, gun-launched rocket for antitank use. May be obsolete; large numbers in satellite nations & Middle East.
	T-6	BR		5.2	3-5	P;O	Artillery barrage rocket; projector-launched.
	Comet-1	SS			90-100	P;Q	Sub-launched (undersea) solid propellent rocket.
	Comet-2	SS			500-700	P;D	Sub-launched (undersea) solid propellent rocket.
	M-100A	GAR	6-8	6-10	5	P;Q	Guided air-to-air missile; solid propellant rocket.
Research	T-3A	Satellite				P;D	3-4 stages. 1 ton payload. Pole-to-pole orbit, 125-1,000 mile. May use T-2 or T-3 hardware.
	POL-1		10-15	10		T	Mach 4 test vehicle, two stages. Stage 1: cluster of 4 solid propellant rockets; Stage 2: M-100A type.
	POL-2		20-25	25		T	Single-stage rocket similar to T-7A. Geophysical studies from 50-100 miles. Four triangular aft fins, short nose cone; payload 50-100 lb.

BR: Ballistic Rocket
G: Gun
SS: Surface-to-surface
GAR: Guided aircraft rocket
P: Production
O: Operational
O: Qualification testing
D: Development
T: Testing

Russia's Ballistic and Long-Range Aerodynamic Missiles

Model	Mission	Type	Length (ft)	Diameter, Max (ft)	Thurst (lb)	Range (Mi)	Status	Notes
T-1 (M-101)	SS	MRBM	50	5.5	77,000	400	P;O	Single-stage, improved A4 (V-2) LOX-kerosene motor Impulse: 4.6 million lb sec
T-2 (M-103)	SS	IRBM	100-125	15	Stage 1: 254,000 Stage 2: 77,000	1,800	P;Q	Two-stage, improved A-4-A9 Stage 2 is T-1 Impulse: 20.4 million lb sec Wt.: 75-85 tons
T-3 (M-104)	SS	ICBM	100-160			5,000	D;T	Two or three stages May use T-1 or T-2 components Wt.: 100-150 tons
T-4 (M-102)	SS	IRGBM	50	5.5	77,000	500-1,000	P	Winged T-1
T-4A		RB				4,000-10,000	D	Two-stage, improved Saenger antipodal bomber Track launched by rocket sled Bomber wt.: 100 tons Impulse: 60.74 million lb sec
T-7A	SS	SRBM	25	2.5	17,600 for 30-60 sec	30-60	P;O	Total launch wt.: about 8,800 lb Truck launched (vertical) HE or nuclear warhead Solid composite propellant

SS: Surface-to-surface
MRBM: Medium-range ballistic missile
IRBM: Intermediate-range ballistic missile
IRGBM: Intermediate-range glide-ballistic missile
ICBM: Intercontinental ballistic missile
RB: Rocket bomber
SRBM: Short-range ballistic missile
P: In production
O: Operational
Q: In qualification tests
T: Test
D: Development

sand kilometers exist at the present time." In a newspaper article the following month, Gen. Pokrovsky cited the statement of December 1953 as having said that "rocket weapons existed which had a range of thousands of kilometers."

The original was considerably less exact and emphatic than this.

Beginning in January 1956, a new serious line appeared in Soviet published statements. On Jan. 28, 1956, in a broadcast on the East German Radio, Frankenberg asserted that Gen. Doolittle, Senator Jackson, and the Alsop brothers were correct in their stated beliefs that the Soviet Union was ahead of the U.S. in developing intercontinental missiles.

Frankenberg declared that: "The Soviet Army, naturally, has at its disposal rocket artillery and long-range missiles." But he went further: "The overseas bases of the U.S. Strategic Air Command could not at present be protected from destruction by rockets." He did not, on this occasion, state that an intercontinental rocket existed, but by indicating that all overseas U.S. air bases were vulnerable, he implied existence of a Soviet IRBM with at least a 1500-nautical mile range.

In February 1956, at the Twentieth Congress of the Communist Party of the Soviet Union, Anastas Mikoyan spoke of Soviet ability to deliver nuclear and thermonuclear bombs "by aircraft or rocket to any spot on the globe." Marshal Zhukov, on the same occasion, spoke of Soviet possession of "powerful rocket and missile armament of various types, including long-range rockets."

These statements were reiterated by other senior Soviet military leaders, on such occasions as Armed Forces Day in February 1956 and February 1957. These statements did not specifically refer to intercontinental rockets, although the one by Mikoyan strongly indicated their existence.

The most emphatic communist statement up to that time was made in March 1956. In another broadcast Frankenberg stated that the Soviet Bloc "now possesses atomic intercontinental ballistic rockets which are capable of reaching any given point in the territory of an aggressor."

One month later Krushchev said in England: "I am quite sure that we will have a guided missile with a hydrogen bomb that can fall anywhere in the world."

Col. Metreveli admitted in MILITARY KNOWLEDGE (December 1955), that long-range ballistic missiles are "intended for firing against strategic targets disposed in the deep rear of the enemy."

Raymond L. Garthoff, for seven years the specialist on Soviet military affairs for the USAF Project RAND, and author of the authoritative book, SOVIET MILITARY DOCTRINE *(1953), presents here some previously unpublished data. He is probably the only researcher in the West to have surveyed all available military, scientific, and popular periodicals and other literature published in the Soviet Union over the past twenty years. The views expressed by the author are his own.*

Insofar as the IRBM is concerned, its potential for action against SAC overseas air bases has been emphasized. In this connection, Frankenberg's commentary of January 1956 made note of a crucial difference in an attack by the IRBM from attacks by bombers: time would not permit the enemy aircraft to evacuate these bases.

Missiles vs. Bombers

One question which arises in an evaluation of the intermediate and intercontinental ballistic rockets is their role in relation to other weapons systems with similar capabilities, particularly long-range aviation. The question was posed by Maj. Gen. Tatarchenko in the official HERALD OF THE AIR FLEET in 1946: "Can long-range rockets replace bomber aviation?" His comments, although ten years old, remain the most complete Soviet view available. It should be noted, however, that his point of departure was the British and American views on the subject, and that Tatarchenko himself, to a unique degree, sometimes expressed views at variance with the official Soviet concept. This is what he wrote:

One of the arguments for the replacement of bomber aircraft by rockets is that in the future, with perfected "thinking" antiaircraft projectiles, with the use of supersonic jet fighters with powerful artillery armament, giant bombers will simply be an unprofitable and ineffective means of long-range action.

Therefore, it seems that it would be cheaper and more reliable to send a corresponding tonnage of bombs in the form of rocket missiles. These rocket bombs, even if they did not reach their target, would despite their cost, be incomparably cheaper than hundreds of enormous aircraft, to say nothing of the absence of crews.

As is well known, in their time the Germans put into action the very same logical conclusion. Rocket bombs were produced almost exclusively, beginning in 1944, for the bombing of London and the southern part of England. They intended to attack New York, and possibly other metropolitan areas of the eastern coast of the U.S. with rocket bombs.

An underestimation of this mighty means of warfare would be a fatal mistake. To even a moderately educated person it must be clear that this new weapon in 1944-1945 appeared in an extremely primitive early form. One can hardly doubt that in the future it will develop significantly further. But does that mean that long-range bomber aircraft have passed their time, and that rocket bombs will completely replace the bomber in the air? Of course not! As the battleship did not replace the cruiser, nor the mine layer, nor the cutter, nor even the rowboat, similarly even the most grandiose development of rockets will not eliminate the necessity for any class of aircraft, least of all high-speed aircraft—bomber and transport.

High-speed giant aircraft are the foundation of strategic aviation. Missions of this form of aviation are extremely varied and cannot be accomplished with rocket bombs alone. Rocket missiles are a means of destroying stationary targets which occupy considerable area. The realm of use of rocket missiles is fairly specific. Strategic aviation resolves many times more universal missions.

While these may have been Tatarchenko's own ideas, there are indications that in general these views probably represented the attitude of the Soviet Long-Range Air Force staff at that time. Marshal of Aviation Skripko, then Deputy Commander of the Long-Range Air Force, stated in RED STAR later in 1946:

It is entirely obvious that with the contemporary level of technology the operation of formations of long-range aircraft with well-trained crews will without doubt be more effective than the dispatch of "blind missiles" alone. Strategic aviation will develop along with the appearance of new aviation weapons.

And the Soviets have acted accordingly.

More recently, in 1954 and 1955, Soviet military writers have commented on American efforts to build a strategic missile system along with the maintenance of strategic air forces. One writer, Lt. Col. Alexandrov, stated in the HERALD OF THE AIR FLEET that in the view of "some American military specialists . . . guided missiles will, in the future, replace bombers."

On the other hand, Lt. Col. Safonov, upholding the view of aircraft dominance, noted in the same journal that other foreign sources have noted that "even in 1960" ballistic missiles "will have a range not exceeding 500-600 km." and cruise-type guided missiles "not over 1000 km." range. In view of its appearance in late 1954, this gross understatement is curious and interesting. Col. Safonov then concluded with a statement which would appear to be at variance with many calculations on high-yield weapons' accuracy requirements: "An atomic missile, as a big expensive weapon, must

be delivered accurately on the target."

Maj. Gen. G. Pokrovsky said in a book in November 1956: "The German Communist military commentator, Frankenberg, whose allegations of present Soviet possession of an ICBM we have cited, nonetheless also has stated (in January 1956) that the long-range rocket weapon 'can, in certain circumstances, cause havoc, but its accuracy in hitting the target depends on many uncertain factors.' "

In the Soviet view, while the general role of bombers will continue for a long time, missiles will assume the burden of attacks on stationary strategic targets.

In the words of Maj. Gen. Pokrovsky, writing in an authoritative limited-circulation military organ in early 1955: "The destruction of targets, the coordinates of which are known in advance, will more and more be accomplished by pilotless weapons armed with atomic and thermonuclear warheads."

Again in March 1957, Gen. Pokrovsky wrote in the magazine MILITARY KNOWLEDGE of the future employment of long-range missiles against "targets previously known and precisely located on the map."

In early 1957, Engineer Lt. Col. Tiurnin, in RED STAR, noted the following advantages of missiles over bomber aviation: (1) the possibility of using mobile launchers, (2) the all-weather capability of guided missiles, (3) the opportunity for the use of missiles even under conditions of hostile general air superiority, and (4) the possibility of launching surprise blows from concealed launching points.

As one of various improvements in manned bomber systems, Red Star recognizes that: "Aviation guided missiles (air-to-surface missiles) can be employed for operations against strategically important targets having strong air defense."

One alleged Soviet source, the authenticity of which is still undetermined, is purported to be a pamphlet, presumably written by the Soviet Air Force command, published in October 1953: THOUGHTS ON AIR STRATEGY. This is said to state that the long-range bomber is obsolete, and that the ICBM is faster, simpler, less expensive and less vulnerable.

American development is said to be inferior and is criticized. In conclusion it is said, "Today's giant air bases will become bomber cemeteries in a future war." While the authenticity of this source is undetermined, the conclusions would seem consonant with Soviet thinking, with the important qualification of their reference to the future.

For the present and immediate future, it is clear that the Soviets are continuing to consider necessary the procurement of large numbers of long-range manned bombers of the *Badger, Bison,* and *Bear* types.

In the distant future another possibility is seen: nuclear propulsion of rocket missiles. As early as September 1945, Lt. Gen. of Artillery Nesterenko raised this possibility in the authoritative MILITARY THOUGHT. Again, in early 1947, Lt. Gen. of Artillery Kuleshov wrote about the possibility of using nuclear propulsion to "increase the speed, range, and power of rocket projectiles." A long silence followed during the period of intensive postwar censorship (1947-1953), but since 1954, a number of Soviet sources have written with implicit optimism of the possibility of nuclear propulsion for rockets.

One general statement, in 1954, mentioned rockets' potential for accuracy and unlimited range. Professor Kosmodemiansky wrote in a booklet: "Rocket projectiles can be shot to any distance. Contemporary successes of radar and teleguidance make possible the achievement of satisfactory accuracy in hitting the designated target."

It is from this perspective that the Soviets see the growing role of long-range ballistic missiles gradually replacing many but not all the missions of piloted bombers.

USSR Army Gets IRBM, ICBM

As we have observed, in the early postwar period several artillery generals stressed the importance of long-range missiles. In the postwar research and development program, both artillery and air force officers and institutions have played important roles. Chief Marshal of Artillery Voronov has been reported, at least as of several years ago, to have headed the whole missile program. Marshal of Artillery Yakovlev has also been active in this work.

Development of rocket propulsion units, and such work on guided pilotless bombers as has been done, have been directed by the appropriate air force agencies. Work on ballistic rockets has apparently been conducted under artillery supervision. The head of the Technical Sciences Section of the USSR Academy of Sciences is Academician A. A. Blagonravov.

Recently, several Soviet generals and marshals of artillery have been permitted to state publicly (in Col. Gen. Fomin's words in November 1956) that "long-range rocket weapons of intermediate and strategic types . . . constitute *a form of artillery*. Now artillery can be employed . . . beyond the limits of the tactical zone of operations of the ground forces."

Col. Gen. Samsonov similarly spoke of long-range rockets as "a variant of rocket-firing guns. Thus we witness a new qualitative leap in the development of *artillery*."

Marshal of Artillery Chistiakov declared that "rocket artillery can be employed for firing atomic projectiles not only in the tactical zone of operations of the ground forces and in their interests, but also *along with* (not as part of) long-range aviation for strategic purposes." No air force spokesmen have been permitted to make similar statements.

Ultimately the ICBM (and probably the IRBM) may well be absorbed in an autonomous long-range force combining this ballistic missile artillery with long-range manned (and, if employed, pilotless) bomber aviation. Meanwhile, the ground forces have operational control over all ballistic missiles up to about 1000-mile range, and probably will get some of the IRBMs.

The Soviet Navy has been permitted to develop and adapt both ballistic and guided missiles up to and probably including an IRBM for use from submarine and surface vessels, and possibly for coastal defense (which is a naval mission in the USSR). For submarine launching, emphasis to date has been on nonballistic guided missiles.

One of many statements reflecting the Soviet interest in submarine missile launching was made by Rear Adm. Pavlovich (March 1957) in SOVIET FLEET: "The possibility of using submarines for action against industrial and administrative centers of the enemy by long-range guided missiles has advanced a whole series of new requirements in combat ordnance." In addition the Soviet Navy has been developing an air-to-surface missile for use against enemy ships at sea.

IRBM, ICBM Invulnerability

General Pokrovsky in SCIENCE AND TECHNOLOGY IN CONTEMPORARY WARS, a book published in October 1956, has spelled out most explicitly the Soviet evaluation of relative invulnerability. He stated:

> In firing long-range rockets each rocket can be launched from an individual launching pad, and moreover these launching platforms can be constructed relatively quickly, quite dispersed, and well concealed. Their detection by the enemy, prior to the launching of the rocket, can be made difficult, and in any case more difficult than the detection of airfields. Therefore it will be very difficult for the enemy to prevent the launching of a rocket.

As regards interception of a missile once launched, he calls attention to the fact that:

> . . . in flight, a long-range rocket has

extremely great speed . . . One can suppose that a long-range rocket, launched by the enemy by surprise, will be detected by radar only several tens of seconds before the moment of detonation, and too little time will remain for a normal alarm and shelter of people. Thus a long-range rocket in practice achieves surprise of attack on a distant target. A massed blow of long-range rockets, launched by surprise by an aggressor against a peaceful country will be especially powerful because in peacetime the launching pads and rockets on these launchers can be prepared in concealment without possibility of reconnaissance and destruction by the defender . . .

The speed of a long-range rocket prevents its interception and destruction by conventional flying means, artillery fire, *or any other means.* It is possible that some counterweapon will be found. However, without doubt for quite awhile the probability of destruction of the rockets cannot be very great.

Defense Against U.S. Missiles

Until very recently there have been virtually no Russian reports on specific problems of defense against American ballistic and guided strategic missiles. In a rare statement (December 1956) an East German radio commentator declared that while defenses exist against guided missiles, "no defense exists against ballistic rockets. No absolutely effective weapon exists at present to counter this type of rocket weapon."

Since spring 1957 a few brief reports have been made of such defense measures through Soviet sources.

Maj. Gen. Pokrovsky, who has on other occasions been permitted to break through censorship (for example, to discuss long-range missiles, in March and April 1944), first mentioned this problem, in the March 1957 issue of MILITARY KNOWLEDGE.

In discussing American nuclear delivery systems, he stressed "the great difficulty" of intercepting long-range missiles, but without elaboration. Later in March, Lt. Col. Engineer Nikolaev wrote an article in SOVIET AVIATION, "Problems of Interception of Intercontinental Pilotless Means of Attack."

This awkward Soviet designation includes, of course, both cruise-type guided missiles and ballistic rockets. Col. Nikolaev's main theme is that basically the problem of defense and interception is the same as against bombers, and the weapons systems are thus fighters and antiaircraft artillery rockets.

On the whole, his report is important only for the fact of its existence. But one point is of interest. He declares that: "It is necessary to note that in the event of the explosion of a thermonuclear warhead even at a distance of 30 to 40 kilometers from the air defense weapons, the latter will receive significant damage and will be overcome (sic) by radioactive contamination."

It is curious that he doesn't note the similar effect of an intercepted but detonated charge on the *primary* target, but limits his comment to the effect on the air defense installation. This could mean that the Soviet air defenses are so deployed that they might be subject to damage in cases where the primary targets are not.

These comments on problems of defense against missile attack cover only some aspects of active defense. It is still true, and well appreciated by the Soviets, that (in the recent words of Rear Adm. Kruchenykh) "defense against missiles must consist in dealing pre-emptive blows on their launchers;" that is, hit them before they can be fired.

In a book published in November 1956, Maj. Gen. Pokrovsky stated:

The most effective defense against such long-range rockets is by means of their destruction in the storage places, on the paths of their transport, and on the launching platforms, where the preparation for each firing takes a rather long time. Unfortunately, one must keep in mind that the launching platforms for long-range rockets do not require very complicated preliminary equipping, and therefore, can be deployed in the most unexpected places, where helicopters can quickly bring the components of the rocket and the necessary equipment for assembly and firing. Long-range rockets can also be launched from warships, in particular from submarines.

Soviet Claims

Since early 1956, the Soviets and the East German Communists have on several occasions bragged that America lagged behind the USSR in missile development. The most extreme boasts have been made in East German commentaries. Thus, military commentator Frankenberg in January 1956, cited statements of Gen. Doolittle, Sen. Jackson, and the Alsop brothers to the effect that Soviet progress is ahead of that in the U.S. and that these were statements "whose correctness need not be doubted." In March 1956, he said that in rocket development "the USSR can never be overtaken" by the West. Another commentary was made by Kurt Shulz in December, 1956. He said:

In recent years it was believed in the U.S. that guided missiles were superior to ballistic missiles as regards range and accuracy. Accordingly, missiles controlled (guided) by various devices were created in the U.S. But all of these techniques have considerable shortcomings. They call for elaborate electronic devices built into the rocket, and for a close-knit radar network for guiding the missile. The main weakness is the high degree of vulnerability of the apparatus to electronic interference of all kinds (ECM). The Americans have only recently realized their mistake and concentrated all their efforts on the making of unguided ballistic rockets. *They are lagging ten years behind the Soviet Union, which took this path from the outset* (e.g., right after the war).

Another East German commentator, in June 1957, explained continued American interest in overseas bases, as follows:

There is, first of all, the *inadequate range and insufficient reliability* of U.S. intercontinental missiles. The intercontinental *Atlas* missile, with a range of from 6000 to 8000 kilometers, will be ready for use by the forces only in three years' time, according to U.S. reports, and it is a moot point whether these reports are based on facts. The constant chain of disaster, to which a large part of the newly developed U.S. missiles and remote control devices have recently fallen victim, will not be without effect on the further development of these weapons.

Meanwhile, since acquisition of "medium-range rocket weapons," it is said that "even greater progress has been made in developing rocket weapons in the Soviet Union. Western reports speak of two missiles with a range of 3000 to 10,000 kilometers."

Such statements as these serve a propaganda purpose and must be considered in that light. But it is true that information available, such as the account of former German scientists who worked on missile development in the Soviet Union from 1946 to 1953, do indicate an early and continuing Soviet stress on ballistic rockets, and after a few years practically none on nonballistic guided missiles.

Soviet accounts have, on a few recent occasions, also criticized alleged American inferiority in the missile field, although not with the same intensity and scope (nor disclosure of their own work) as have the East German Communist sources.

In February 1957, when Radio Moscow interviewed Academician A. A. Blagonravov (who is also a lieutenant general of artillery technical services), he stated:

The data at our disposal (not otherwise identified) show in many instances much more efficient results in this direction (experimental stratospheric rockets) than those achieved abroad—this makes our experiments more valuable than the American ones.

Similarly, late in May 1957, SOVIET AVIATION criticized the *Nike* as vulnerable to evasive action by high speed modern aircraft, and concluded that "as it now exists, the highly praised *Nike* system is far from perfect." ★

CANADA . . .

No Missiles – but Facilities and Experience



By George Shaw

OTTAWA, Que.—Canada's guided missile industry is pretty much a collection of odds and ends from the missile program in the U.S. and U.K., and though there is evidence of some original research in the field, there is no missile.

The one attempt to develop a missile in that country began in early 1951, when a group of scientists in the Canadian Armament Research and Development Establishment at Valcartier, Que., embarked on a project to create an all-Canadian air-to-air missile. Called the *Velvet Glove*, the weapon was geared specifically to the Avro CF-100 interceptor.

In all, some $24 million and about five-years' work were poured into the project before a change in government policy brought about its termination. Supporters of *Velvet Glove* insist that it was superior to the *Sparrow 2*, for which the Canadian government is currently negotiating.

Critics of the weapon maintain that *VG* was obsolescent when work first began on it in 1951, and they go so far as to say that the government lacked faith in the missile to the extent of blocking production of the almost-finished product.

Unhappily, very few of the arguments for and against the *Velvet Glove* will ever be proved or disproved, for even at this late date an unrealistic "security blanket" shrouds all but a few minor details of the weapon. And, too, many of the people involved in the project would be happy to forget *Velvet Glove* and turn to production of the *Sparrow 2*.

Production of the *Sparrow* might possibly have been started months ago but for the Canadian government's insistence that the entire missile be handed over under a single-type certificate. Many of its components are produced under separate certificates, and the process of bringing them together under one certificate has already consumed about a year.

Latest estimate is that the *Sparrow* will not go into production in Canada until at least the middle of next year.

Meanwhile, to further complicate the missile picture, Canada has acquired a new government, the first change in more than 20 years. The new defense minister has stated publicly that his department will take "a close look" at all contracts made in the recent past and affecting the present defense production picture. The contracts for *Sparrow* production have been negotiated but to date none has been signed, and one plant official said, "without a signature we can't do a thing."

The possible over-all prime contractor for *Sparrow* will be Canadair, since that company handled the *VG* contract and has gained more experience in missile hardware production than any other company in Canada. Canadian Westinghouse was prime contractor under Canadair for the electronics systems.



NIKE to defend Canadian cities.

Other companies involved in the old project were Avro, de Havilland Canada and Computing Devices of Canada. Government agencies, beside CARDE, were Defense Research Board, National Aeronautical Establishment and the RCAF. Former superintendent of the Ballistics Wing, CARDE, and leader of the original research team was Gordon D. Watson. Watson is now director of weapons research at Defense Research Board headquarters in Ottawa.

Most everyone in touch with the old *VG* project is agreed on one point: missile or no missile, the money was well spent.

Today the Defense Research Board has a core of experienced and able scientists and engineers who have had a hand in building a missile. That experience could not have been gained in any other way.

DRB and RCAF have acquired valuable know-how in testing and firing ballistic missiles and have established facilities and ranges for handling any future weapons effectively.

Canadian industrial concerns have gained firsthand knowledge of the problems and techniques of missile production. The companies involved in the *Velvet Glove* program can swing into production of a weapon such as *Sparrow* with a minimum of delay, and they all seem very anxious to "get started."

Testing centers for any future missiles will, no doubt, be the same as for *VG*. CARDE has a ground-test ballistic range at Valcartier equipped for making resonance studies, speed tests and other tests than can be made with ground facilities.

Point Petre Range, near Picton,





NIKE control plane (L) and Canadian crew (R) at joint Canadian/American exercise in the use of NIKE missile at Churchill, Manitoba.

Ont., is a short-range test-firing facility located near the Royal Canadian Artillery center at Petawawa, Ont., and close to the RCAF station at Trenton.

RCAF Station Cold Lake, Alberta, played a major role in the air firing tests of *Velvet Glove*. Station Cold Lake is the only RCAF base completely planned in the postwar period and is one of the most modern training and testing establishments in the world.

Development of the Cold Lake establishment was initiated to satisfy a critical need for a weapons range and proving ground to replace the older, inadequate ranges the services found themselves with after World War II.

Operated by RCAF Air Defense Command, Station Cold Lake is home base for the Weapons Practice Unit, Operational Training Unit and the Central Experimental and Proving Establishment. The station also operates a practice range about 30 miles north of Cold Lake which is 114 miles long and 40 miles wide.

In conjunction with the Primrose Lake range, nearby Cold Lake range is used to evaluate rockets and missiles where air-to-air firing is desired and long range tracking is necessary. Telemetering and ground-controlled intercept stations are maintained at the ranges, as well as modern high-speed photographic tracking equipment.

Each of the nine CF-100 squadrons in Canada visits the Cold Lake station periodically to practice the latest methods in lead-collision course interception, rocket-firing practice and missile testing. Reliability of the CF-100's fire-control system is tested periodically on the vast ranges.

Primrose Lake, a few miles north of Cold Lake, was the primary tracking and control range used in the *Velvet Glove* project and presumably will be used in the new *Sparrow* program when it is instituted next year. Sparrows have already been tested at the Cold Lake and Primrose establishments and it is extremely likely that RCAF units are currently engaged in exercises with the missile.

Located along the shores of Primrose Lake are nine theodolite stations used in checking velocity, trajectory paths and homing characteristics of guided missiles. The theodolites have a clear-day range of 50 miles, and are automatically synchronized for continuous tracking and computing. Digital computers are used in connection with the theodolites for rapid and automatic computation of flight data.

Summing up the missile situation in Canada is greatly simplified by the absence of a home-grown product.

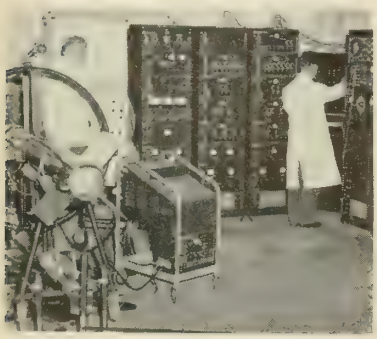
Great Britain and the U.S. frequently test operational missiles jointly with the Canadian Armed Forces, and several hundred Canadians have been in U.S. Army missile centers.

Much up-to-date material on missiles and atomic research is on loan to Canada from the U.K. and U.S., and exchange agreements between the countries have kept Canadian scientists abreast of developments in the two fields.

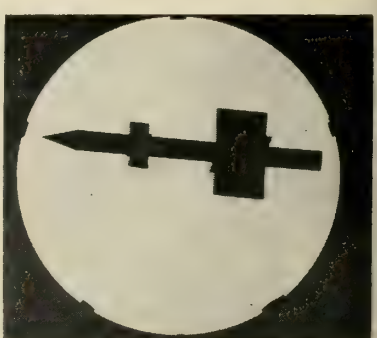
Canada's security system is effective but cumbersome. More experience in declassification of projects such as *Velvet Glove* should eventually result in a more realistic approach to security matters in general.

Enough information on missiles is now available to Canadian scientists to warrant original research on a large scale. However, the population of Canada is about one tenth that of the United States, with a national economy to match. All-out participation in missile research would not be economically feasible.

The logical approach to the missile question seems to be the one they are taking—to use the experience gained with *Velvet Glove* to produce and weaponize finished missiles available to them from Great Britain and the U.S. ★







Canadair test lab with VG model in foreground (L); Rocket being propelled by sabot on CARDE Range (C); Resonance test on rocket (R).

AUSTRALIA . . .

Proving Ground for Commonwealth Missiles

By Seabrook Hull

AUSTRALIA'S MISSILE problems are unique to the country. Its opulation—therefore, its budget—is mited. Its industrial ability cannot roperly cope with missile systems of oo complex a nature. However, hrough its Woomera test range it is aking a major contribution to West-rn missile progress.

And though its population is small less than 10 million), its land mass equiring defense approximates that f the U.S. Obviously, Australia can-ot consider its missile problems from ie point of view of playing the top ole in any future war. It must consider self as part of a coordinated alliance –as part of the British Commonwealth f Nations on the one hand, and as art of the Southeast Asian Treaty Organization on the other. Its major eed, therefore, is for tactical missiles, articularly for air defense.

In missile development, its major ontribution to date is the *Jindivik,* a igh-subsonic pilotless aircraft. Origi-ally conceived as an interceptor mis-sile, its primary mission now is as a target drone. However, studies are under way to determine its feasibility as a surface-to-surface missile of the *Matador-Regulus* type.

One of Australia's biggest missile worries at the moment is for the defense of its major cities—particularly Sidney. For this purpose it will go ahead and is already conducting studies of missiles like *Talos, Nike* and the United Kingdom's *Bloodhound.* No decision has been reached as to which one is favored. But cost and availability, as well as operational ability, are factors. Target for the study is to start installing missiles around Australian cities sometime in 1959.

Royal Australian Air Force prefers the de Havilland *Firestreak* for air-to-air work. This heat seeker may be completely manufactured in Australia. Certain components are already locally made.

The Australian Government does not yet know whether it will buy these missiles outright from abroad or whether they will request licensing authority and manufacture them in Australia. "It all depends on their complexity and demand on natural resources."

Meanwhile, Australia's missile program has not been without its advantages. It recently sold ten *Jindivik* "pilotless aircraft" to Sweden for £500,000 ($1,115,000). Price included ground control equipment and spare parts. The *Jindivik* can top 50,000 feet.

Meanwhile, if any nation has room to spare for an overland missile test site, it's Australia. Thus, the Woomera Range in central Australia is of vital importance not only to Australia's but Britain's missile development. Sooner or later, virtually all of Britain's missiles are tested at Woomera. Also, the Woomera base is being used during the International Geophysical Year for satellite tracking and for launching upper-air research rockets such as Britain's *Rockoon*-like system, the *Bobbin.* ★

Missiles don't do much good in this kind of fighting. Australia's missile arsenal is being tailored to her peculiar needs.











Australia's greatest contribution to the free world's missile effort is the massive overland test range at Woomera where these shots were taken. Upper left is the BOBBIN ramjet test vehicle produced by Bristol Aeroplane Co. It is parachute-recovered. Lower left shows a SKYLARK in its launching tower for firing. Below is the pilotless target plane JINDIVIK. Above is a dramatic view of Britain's FIRESTREAK infrared guided missile just after firing. Virtually all British missiles are tested at Woomera.



GREAT BRITAIN . . .

Takes Lead in NATO Missile Production

By James H. Stevens and Ronald C. Wakeford

BRITAIN'S MISSILE POLICY was announced by Defense Minister Duncan Sandys last April. It was simply that in order to economize defense measures and so reduce the annual budget, the UK would:

1) make the English Electric P-1 (and stretched versions of it) the last manned fighter airplane;

2) make the Avro Vulcan B2 and the Handley Page Victor B2 the last manned bombers;

3) make all interception by missile after interim introduction of a single operational AAM, the DH Firestreak (for Royal Navy as well as RAF use);

4) increase range of second-generation V-bombers by Avro stand-off bomb, pending ICBM;

5) abandon area protection of the British Isles, including population centers and even defense plants, in the face of nuclear warhead missile attack;

6) restrict target defense to the bomber (later ICBM) retaliation bases.

Until very recently there was a widespread feeling that the British missile industry was a damp squib. But for many years now the rumblings at Aberporth, South Wales, and Woomera, Central Australia, have indicated that some form of missile research was taking place, but little was said for publication. But recently, photographic and data releases by the Ministry of Supply have shown that the UK is much further advanced than was generally realized.

A few months ago information presented to Parliament by the Minister of Supply named two missiles (*Firestreak* and *Bloodhound)* and another vehicle (unnamed) to be manufactured by the English Electric Co. Details of the *Sea Slug* were made available more recently.

The Society of British Aircraft Constructors (SBAC) has announced that 400 British companies are engaged in missile development and supporting work.

Most notable of the companies manufacturing missiles are: Bristol Aircraft Ltd., English Electric Co., DeHavilland Propeller Ltd., A. V. Roe, Fairey Aviation and Vickers-Armstrongs. Bristol Aircraft has four plants concentrating their efforts on missile work. Ferranti, manufacturers of guidance equipment, which is associating with Bristol on one of its projects, has two plants giving support to the missile program.

Others include: E. K. Cole & Co. Ltd. *(Fireflash* radar), E.M.I. Engineering Development Ltd., The General Electric Co. Ltd., Sir George Godfrey and Partners, Imperial Chemical Industries, McMichael Radio Ltd., Metropolitan Vickers Ltd., The Sperry Gyroscope Co. Ltd., The John Thompson Conveyor Co. Ltd., Vickers-Armstrongs Ltd.—all *Sea Slug* ancillaries.

Rolls-Royce Ltd. (Rocketdyne License), Avica Equipment Ltd., The British Thompson Houston Co. Ltd.,

A development model of Britain's SEA SLUG fires from the forward triple launcher of the HMS Girdle Ness. Note four typically British wrap-around boosters clamped to missile body.



S. G. Brown Ltd., Burnley Aircraft Products Ltd., Delaney Gallay Ltd., Diamond H. Switches Ltd., Dowe Instruments Ltd., Elliott Brothers (London) Ltd., Goodmans Industries Ltd., Graseby Instruments Ltd., High Pressure Components Ltd., Hymatic Engineering Co. Ltd., I. V. Pressure Controllers Ltd., Kelvin and Hughes Ltd., King Aircraft Corp. Ltd., Laporte Chemicals Ltd., Lion Electronic Developments Ltd., Muirhead and Co. Ltd., W Bryan Savage Ltd., Smiths Aircraft Instruments Ltd., Solartron Electronic Group Ltd., Teddington Aircraft Controls Ltd., Vactric (Control Equipment) Ltd., Venner Ltd., W. Vinter Ltd., Western Manufacturing (Reading) Ltd.

Missile Budget Secret

The actual money spent on the missile program has never been revealed, but is "for security reasons" lumped in with the general aviation vote.

The full scope of the operational weapons program has not been revealed, although rumor has it that Vickers-Armstrongs has not only had its *Red Dean* AAM cancelled, but that the company's ICBM—also well ahead—was cancelled.

Missile bases for testing or indoctrination of personnel are either established or are undergoing construction in several areas. Two of the newer facilities are the RAF missile station being completed at North Coates, Lincolnshire, and the joint services test range, South Uist, Outer Hebrides. The former will see service missile trials in 1958. Some missile development testing has been undertaken at the Royal Artillery range at Larkhill.

Just how far Britain has advanced in the missile field, and what its position is in relationship to the U.S effort, has yet to be established. More information will have to be released before a true picture can be drawn.

British separation and boosts, based on the wrap-around principle, aim at maintaining a minimum vehicle length to facilitate launching, handling and transportation. Wrap-around boosting also keeps C. G. shift at separation to a minimum and requires no additional stabilizing fins. Separation by aerodynamic means is somewhat simpler with tandem boost. Air pressure lifts away the booster units to a predetermined angle before separation is achieved.

The Fairey Aviation Co. was probably the first to make a production missile. Background to this work was the *Stooge*.

FIREFLASH

The history of the Fairey *Fireflash*, which was Britain's first operational entry in the air-to-air missile field, dates back to World War II. At this period the Royal Air Force's need for this type of weapon was fully understood and a series of developmental programs was initiated. During 1953, an early version of the vehicle successfully destroyed a *Firefly* drone.

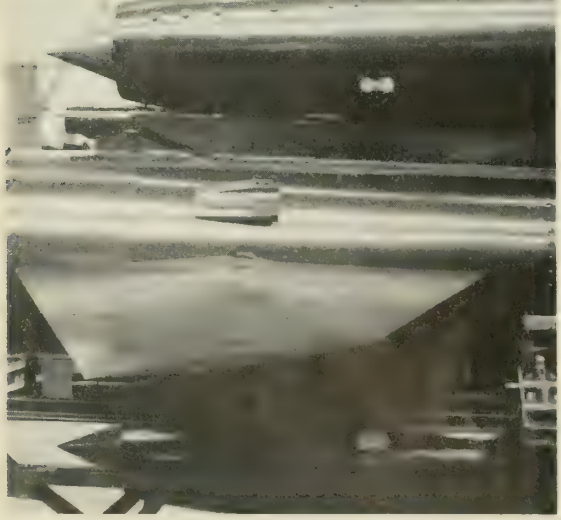
The *Fireflash* is somewhat unique, in that it has no sustainer motor. The solid-propellant boosters of the wrap-around type accelerate the vehicle to maximum velocity and then separate, allowing the missile to coast to the target.

The two boosters jut out well ahead of the proximity-fuzed warhead. The main body is tubular with cruciform wings and guide vanes. This makes a fairly bulky, high-drag missile suited to under-wing carriage, but scarcely to stowage in an internal weapon bay. It uses a Marconi beam-rider guidance system. The missile is homed by the launching airplane and is entirely dependent upon the lock-on capabilities of this aircraft's radar. The equipment includes countermeasures against enemy jamming. *Fireflash* is used on the Supermarine *Swift MK7*, the Hawker *Hunter*, and Australian-built *Avon-Sabre*. It is now a training weapon for Fighter Command.

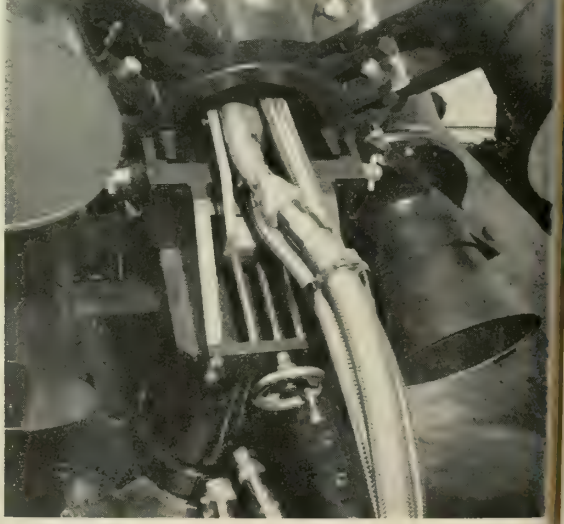
FIRESTREAK

Another air-to-air missile about which the Ministry of Supply has released information is the *Firestreak*. This missile is produced by DeHavilland Propeller Ltd. Passive homing is achieved by means of an infrared seeker. Geometrically the missile is of conventional form with cruciform-shaped wings and fins. It is slated for delivery to the RAF around the end of 1958. The vehicle is now propelled by a single solid-propellant motor.

It is a rather larger missile than the *Fireflash* because its accelerating rocket motor is mounted inside the body of the weapon itself. It is claimed that apart from the electrical and pneumatic activating and launching circuits, an infrared sensing GW requires no special equipment on the aircraft.



A close-up view of the double-wedge five per cent airfoil hinged wing attachment, booster slipper bracket and front of THOR ramjet.



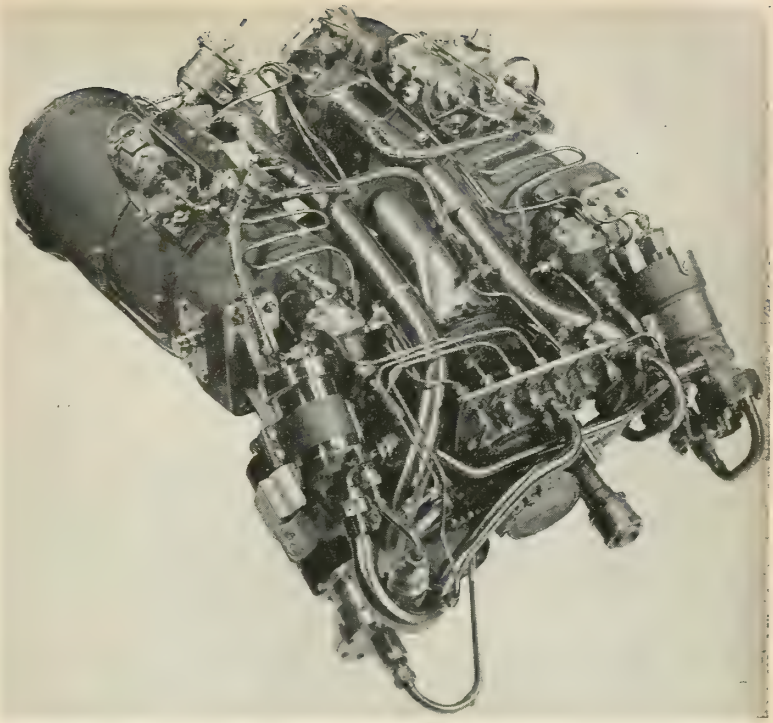
This aft view of BLOODHOUND shows hinged assembly ring for wrap-around boosters as well as hydraulic and pneumatic fittings

As an aircraft, *Firestreak* is a simple supersonic cylinder with cruciform wedge-section wings and tail blades in the same plane. The rearward positioning of the wing is a common supersonic stability feature. Longitudinal strakes appear to be fairings for wing attachments and control leads. Because of the optical nature of infrared wavelengths, the conical nosecap is octagonal in order to provide nondistorting glass "viewing" panels.

Infrared radiation cannot penetrate thick cloud—so prevalent in Northern Europe—but the RAF Air Staff evidently considers that attackers from the East will come in at 50,000 feet, and thick clouds are unknown in the stratosphere.

Two of Britain's RAF fighters, the English Electric P-1 and the all-weather fighter Gloster *Javelin* are scheduled for mating with the *Firestreak*. Royal Navy will also use it on its DH *Sea Vixens*. Range is about eight miles and length approximately seven feet. The *Firestreak* can be teamed with any fighter, the makers claim.

The first production version of the *Firestreak* will shortly be available for export to friendly nations.



Detailed picture of Napier Double SCORPION NSc. D.I. used to attain the altitude in a Rolls Royce Avon-powered CANBERRA. It is a double-barreled version of the NSc. I rocket.

Red Dean

The *Red Dean*, another addition to Britain's air-to-air armament, is believed to have been cancelled. Little information has been released. Vickers-Armstrongs is the contractor. If, as has been reported, this missile has been abandoned, it is probably due to the cancellation of the Gloster *Javelin*. *Red Dean* was tailored to team with this airplane.

Ground-to-Air

Research vehicles bearing such names as RTV 1 & 2, GPV and MTV sparked Britain's surface-to-air missile program and led to such vehicles as *Bloodhound*, *Thunderbird*, and *Sea Slug*. These missiles are now in production.

Bloodhound

The Bristol Aeroplane Co.'s contribution to the nation's defense against air attack is the *Bloodhound* missile. Ferranti Ltd. manufactures the semi-active guidance system. This missile has been under development since 1949.

Sustaining power is supplied by two Bristol *Thor* ramjet engines of "virtually 100% starting reliability," the Bloodhound being boosted to operating velocity on the order of 1500 feet per second by solid-propellant boosters. Hundreds of rounds have been fired from Aberporth and Woomera. This testing will continue at the new range being constructed at South Uist in the Hebrides.

It is a neat little supersonic airplane: cylindrical blunt-tailed body with ogival nose, tapered stub wings with cut-back tips set well aft, rectangular fixed tail plane and one *Thor* above, the other below the fuselage on short pylons. Unlike the symmetrical cruciform rocket missiles and coaster, which are steered by pitch and yaw without banking, the *Bloodhound* is rolled into a bank and turned by elevator action. The reason for this is that the jets from the two *Thors* make it impossible to mount vertical tail surfaces, while the ramjets themselves prevent the fitting of cruciform wings.

The *Bloodhound* wings have no ailerons because all-moving surfaces are best at supersonic speeds. Roll is by differential displacement of the wings, with pitch control by alteration of wing incidence in unison. Concentration of the jacks and operating equipment at the middle of the aircraft is a highly desirable feature, both mechanically and for weight-control reasons.

Construction is simple, expendable stuff—light-alloy fuselage with fabricated light-alloy wings and tail, which have plywood-filled tips. The wing airfoil is a double-wedge, five per cent thick, unswept and hinged on a tubular spar at the mid-chord point. The tail plane consists of two rectangular units bolted to a mounting ring let into the tail of the fuselage, with a one-inch thick airfoil of flat-plate form with leading and trailing-edge entry wedges.

Bristol Aero-Engines's *Thor* ramjets are fabricated from 18/8 commercial stainless steel, mainly by welding. The powerplant is of elemental supersonic form—just a plain tube with centerbody double-shock air intake and convergent-divergent nozzle. All intakes visible in photographs are either dummies or have been retouched so as to conceal the missile's capabilities. The venturi nozzle is formed by a curved internal plate spot-welded to the skin, which is cooled by a row of joggled holes in the outer surface. On a diameter of 15.75 inches and length of 100 inches, the *Thor*, it has been unofficially stated, is capable of delivering 15,000 pounds thrust at M 2.0 at sea level. It has been tested on the *Bobbin*.

At the front of the mounting pylon of each ramjet is a cylindrical air intake for ram-air, fuel and hydraulic turbopumps.

The *Bloodhound* launcher is a robustly-built unit with a hydraulically powered turntable and elevating ram. The launch angle is constant at 45° and the ramp is locked at this angle by hand-pins in the support-truss hinges. Supplies fed thru the ramp to the missile are high- and low-oil pres-

sures, compressed air and multiple electronics—nearly 100 circuits.

Each of the *Bloodhound's* four boost rockets has a thrust ring (mounting the tail stabilizing fin) hinged to a central mounting ring that fits over the missile's tail. At the front of each rocket case is a ring with a W-shaped bracket that has two fore-and-aft lugs sliding into a slipper casting on the missile. At burnout, the boost assembly slides aft a few inches, the front attachments disengage and the cases umbrella outward, so that the whole assembly falls off backward as a cruciform unit.

The *Bloodhound* will be Britain's first production ground-to-air vehicle. The vehicle is backed up by an excellent radar control system, which integrates acquisition radar, lock-on and tracking radar and the launching site equipment into an automatic launching and firing system. This same system is adaptable to the characteristics of other surface-to-air vehicles in production.

THUNDERBIRD

The second most publicized of Britain's surface-to-air weapons is the *Thunderbird*. This vehicle is a product of the English Electric Co. and is believed to be moving rapidly from development status to full production.

Thunderbird is a beam rider, the guidance system being manufactured by Marconi Co. Ltd., and the liquid-propellant powerplant by D. Napier & Son Ltd. Four wrap-around, finned, solid-propellant booster motors provide launching thrust.

It is a straightforward rocket-propelled missile of "classic" supersonic form. It has a conical-nosed cylindrical body, with symmetrical low-aspect ratio tapered wings set well aft and tapered tail-control blades. Some versions were powered by Napier NRE 17 RTP/kerosene liquid rockets, giving over a ton of thrust, but for ease of operation in the field, RAE solid propellants have now been substituted.

As of this writing, practically no information has been given on *Thunderbird*, but it appears to have semi-active homing guidance, designed, developed, and manufactured by Marconi's Wireless Telegraph Co. The essential difference from the *Bloodhound* is that the *Thunderbird* has its own individual and independent radar so that it can be sited anywhere.

The *Thunderbird's* configuration is similar to English Electric's test vehicles. This would indicate that the overall length is about 20 feet and the diameter, 15 inches.

Built to similar specifications, the *Thunderbird's* performance is expected to be generally of the same order as the *Nike-Hercules*. A self-contained mechanical system for ground support of the missile has been developed in common with American counterparts.

SEA SLUG

The Royal Navy's only entry in the missile field, at least as far as official releases are concerned, is the *Sea Slug*. Many companies had a hand in the construction of this vehicle, the most notable being Armstrong Whitworth (prime contractor), General Electric Co. (guidance), and Sperry Gyroscope Ltd. (control system).

The Admiralty makes the point officially that this is a Navy-designed WS and that the contractors are essentially only suppliers—Armstrong Whitworth having full design responsibility, however, for the aerodynamics.

Sea Slug has movable fins with large rectangular wings and is said to be of medium range capable of reaching any altitude at which an enemy fighter intrudes. Wrap-around solid-fuel boosters are provided which separate as the vehicle becomes supersonic.

Although it was first thought that an Armstrong Siddeley liquid rocket-propellant motor would power the final version, the trend to solid-propellant sustainer motors is also overtaking the *Sea Slug*.

Designed as a fleet defensive weapon, the missile began its sea trails a little over a year ago aboard the *HMS Girdle Ness*, a naval guided weapons ship. *Sea Slugs* are fed to the triple launchers on deck automatically and fired remotely.

Shore-based testing of the vehicles was programmed on the Clausen Rolling Platform, a small ship in itself capable of a 10-degree pitch and 20-degree roll.

Air-to-Surface

The British industry has yet to name its first guided missile of the air-to-surface category, but it is known that A. V. Roe is well on its way to producing the first model. This class of vehicle is commonly referred to in British journals as the "stand off bomb."

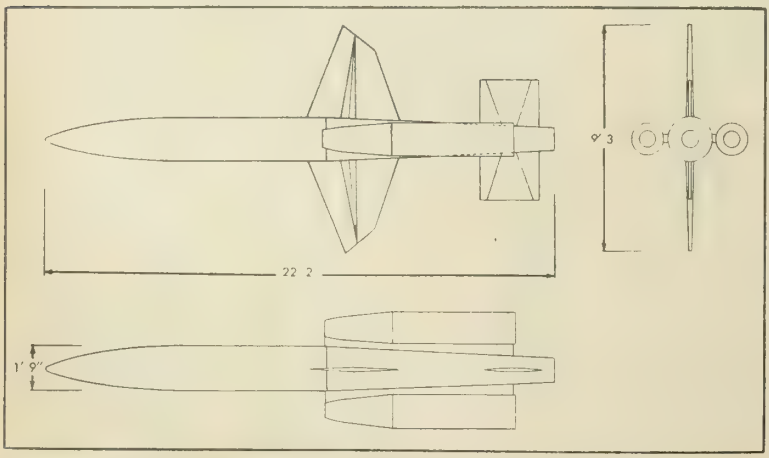
The vehicle is designed to be carried by the RAF's "V" bombers *(Vulcan and Victor)*, and it is believed that the missile will be approximately the same size as the *Rascal*.

Surface-to-Surface

Britain probably obtained its start in the surface-to-surface missile business with a 1916-vintage guided airplane. This vehicle, known as the *Aerial Target*, was a radio-controlled monoplane developed at the Royal Aircraft Factory. More in direct line with recent developments were the British firings of V-2's from Cuxhaven, North Germany, just after the war. At this point all references to activity in this field ceased until very recently.

Today the only development along this line is apparently being undertaken by the DeHavilland Co. which is developing a 2000-mile IRBM in conjunction with Rolls Royce for the RAF. Reports suggest that these two companies have been working on the vehicle for five years or more. The vehicle may be powered by a North American rocket engine made by Rolls Royce.

The Ministry of Supply's Ballistic Missile Division is coordinating the surface-to-surface work through the Royal Aircraft Establishment, Farnborough. The IRBM will carry a nuclear warhead. Meanwhile, the U.S. *Honest John* is used for training; the *Corporal*, for bombardment. An anti-tank weapon is being developed by Fairey Aviation in the smaller category of surface-to-surface vehicles. This missile will probably be used for air-to-ground applications also. ★



Plan views of Britain's main ground-to-air missile effort, the Bristol-Ferranti BLOODHOUND.

SWITZERLAND . . .

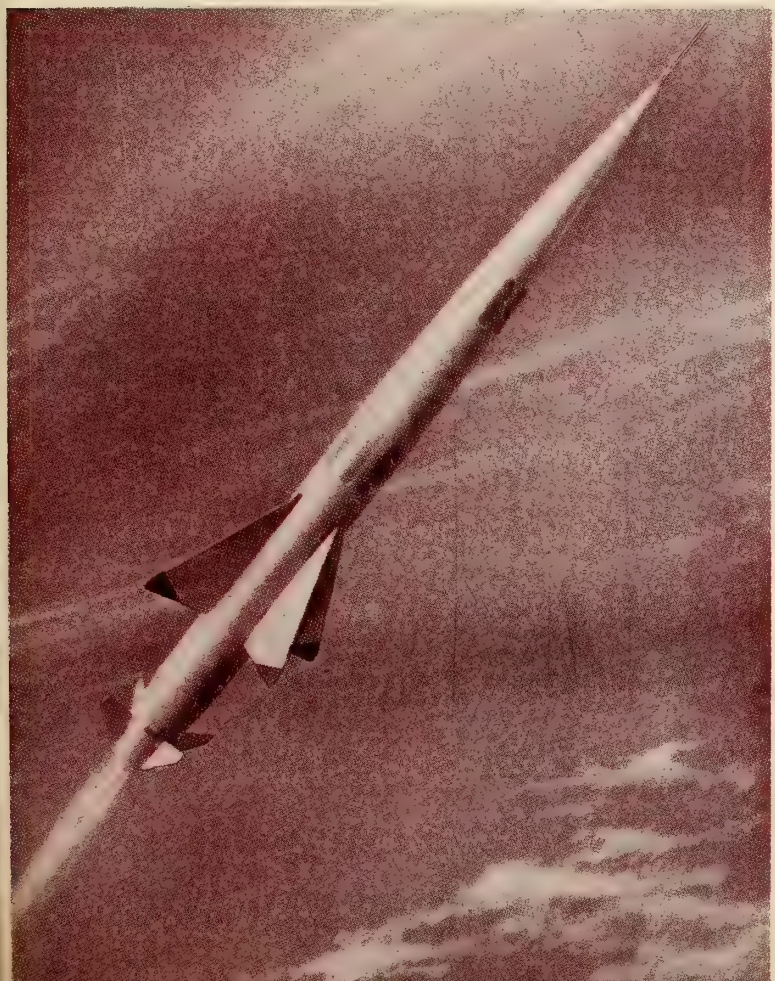
Missile Design with Watchmaker Precision

By Frederick C. Durant III

THE SWISS MISSILE industry and Oerlikon are virtually synonomous. The reputation and achievements of Oerlikon have been carried over from the field of conventional weapons to guided missiles, currently produced by the firm for use by Switzerland and various foreign countries. Of the company's production missiles, two stand out—the Type 50 series SAM and the *Cobra* series antitank rocket.

Development of this antiaircraft weapon commenced shortly after the past war. The Type 54 is a slim, streamlined, rocket-propelled weapon, capable of interdicting aircraft at altitudes up to about 50,000 ft. It is single staged, fired from a dual-position zero-length launcher. Overall dimensions are about 20 ft. long and 16 in. in diameter; launching weight is 770 lbs. The missile has two sets of cruciform wings. The main (forward) wings, which provide lift necessary for controlled flight, move forward to adjust for center of gravity shift during powered flight. The after wings are used for gas-jet steering after burnout.

Oerlikon's Type 54 antiaircraft guided missile.



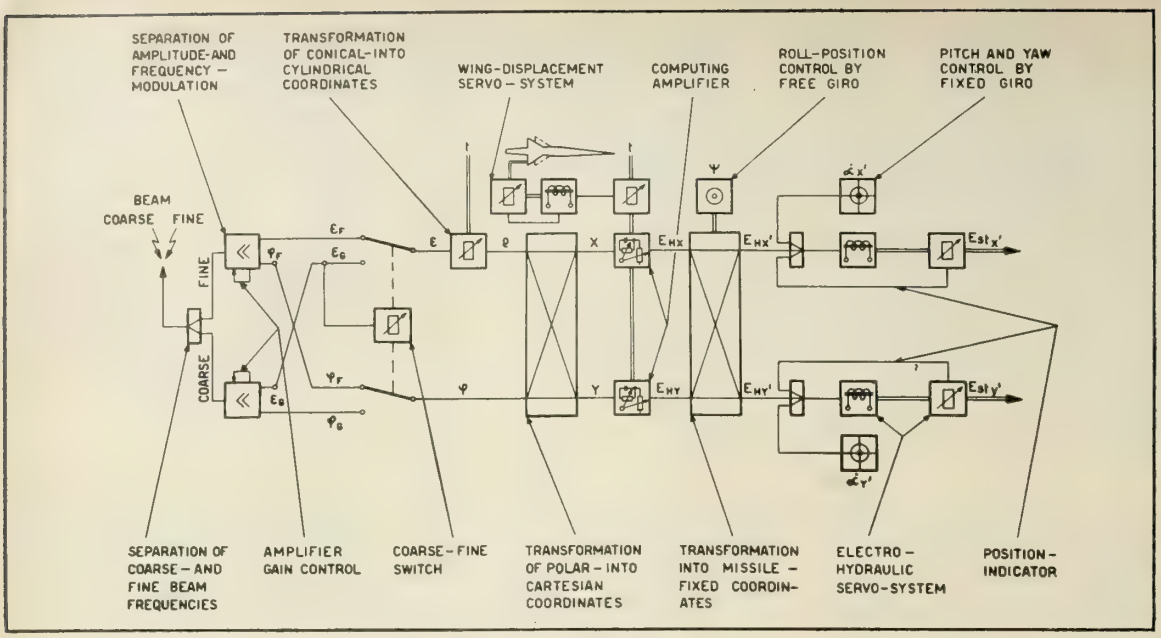
The propulsion unit is a liquid propellant, nitric acid-JP type system which produces a thrust of about 2200 lbs. for 30 seconds. Propellant supply: compressed nitrogen gas at 300 atm. pressure, initially. Specific propellant of the engine is about 12 lb./ton/sec. A starting fuel of triethylamine and xylidine is used to obtain smooth ignition. No booster unit is employed. Burnout altitude is about 30,000 ft.

Fuselage construction is of wound aluminum alloy utilizing metal-bonding adhesive. The wings are of sandwich construction.

Guidance of the Type 54 is a beam-rider system. Ground units operate a radar target tracker and guidance beam path simultaneously. The missile is launched into the guidance beam and rides the center of this beam. The target-tracking radar feeds information on azimuth and elevation angles through a ground computer (to correct for parallax) to the missile guidance beam which guides the missile to target. A proximity fuze fires the warhead if actual impact is not obtained.

This weapon system is complete and has been available for purchase for nearly three years. In addition to Switzerland, Sweden and Italy are also employing this weapon. Japan has recently acquired a license to manufacture. The Type 56 model is an improved version and a newer, Type 57 version is known to be under development.

The *Cobra* is a wire-controlled, solid-propellant rocket antitank weapon.



Above is a schematic diagram of the Oerlikon rocket control system showing the main components and their relationship to one another.

Closely resembling the French *SS.10* and *ENTAC* in size and design, the *Cobra* is manufactured by Oerlikon-Contraves-Boelkow. All these weapons are a follow-on of the German World War II development, the *X-4*. Weighing about 24 lbs., maximum range is slightly less than one mile. Maximum velocity is about 190 mph. Like the similar (but shorter-ranged) shoulder-fired Bazooka rocket, an armor-piercing shaped-charge warhead is utilized. The *Cobra* weighs only about one-tenth of the U.S. Army *Dart*, a similar wire-controlled weapon.

Although unguided, mention should be made of the outstanding 5-cm. and 8-cm. FF,FF (forward firing, folding fin) rockets. These highly effective air-to-ground rockets have been developed for the Gloster *Meteor* and *Venom* aircraft. Launching is from streamlined pods. The *Meteor* carries 76 5-cm. rockets which are fired in pairs at intervals of 0.1 sec., the complete salvo occurring in about 3.5 sec. The *Venom* carries two launchers slung beneath the wings, each carrying seven 8-cm. rockets and firing in pairs. Impact-fuzed, shaped-charge warheads are utilized. A proximity fuze is under active development. Electric power to operate a miniature radar unit is obtained from a gas turbine generator driven by gas "bled" from the rocket combustion chamber in flight. The warhead is fired at the moment the reflected radar signal from the target begins to diminish in strength. ★

Two versions of the Oerlikon antiaircraft guided missile shown being launched. The missile is steered by a combined gas-jet rudder. Four cruciform delta-wings produce the lift force necessary for curved flight, while the four rear fins act as steering controls.



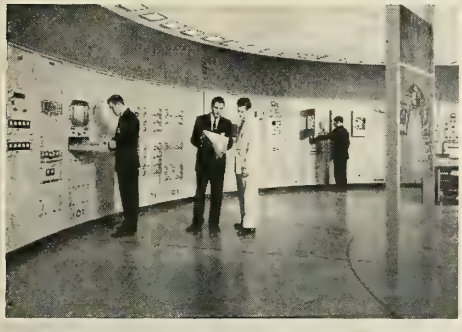




30-channel, analog-digital converter connecting 300-amplifier analog computer to 1103A digital computer



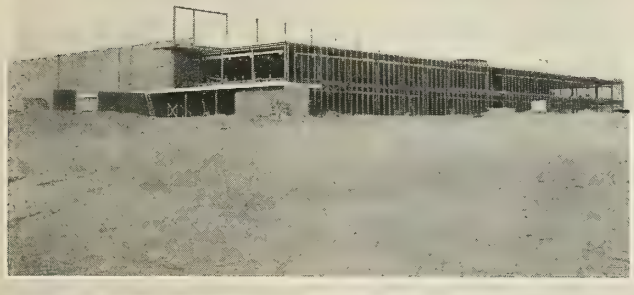
Production of communications equipment in new Los Angeles manufacturing plant



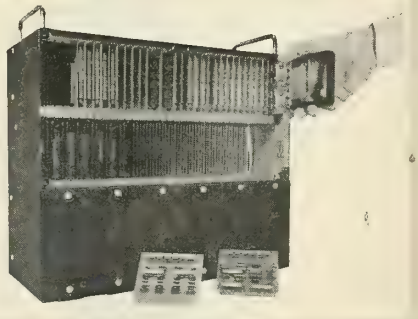
Data Reduction Center designed and built by Ramo-Wooldridge



One of three new research and development buildings completed this year



First unit of Denver manufacturing plant now nearing completion



Input-output unit of the Ramo-Wooldridge RW-30 airborne digital computer

Pictorial **PROGRESS REPORT**

The photographs above illustrate some of the recent developments at Ramo-Wooldridge, both in facilities and in products. Work is in progress on a wide variety of projects, and positions are available for scientists and engineers in the following fields of current activity:

- Communications and Navigation Systems
- Digital Computers and Control Systems
- Airborne Electronic and Control Systems
- Electronic Instrumentation and Test Equipment
- Guided Missile Research and Development
- Automation and Data Processing
- Basic Electronic and Aeronautical Research

The Ramo-Wooldridge Corporation

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FRANCE . . .

Advancing Missile Science Through Uninhibited Thinking

By Frederick I. Ordway, III

FRANCE has accomplished much, with relatively limited resources, in the missile field. She has realized that success can come only by following certain limited avenues of research and development, and it is obvious to her that it is impossible to attempt to create broad categories of highly costly and complex long-range missiles such as found in the U.S. and USSR.

Like its airplanes, French missiles are specialized, and result from a careful assessment of the kind of war in which the nation might become involved. Keeping this specialization in mind, and looking forward to closer R&D cooperation between European NATO powers, it is probable that French missilry will become an increasingly important factor in European defense in the years to come.

Since the war France has moved into the forefront of world rocketry. They enlisted the aid of a number of German scientists, including Sänger, Sänger-Bredt and Zborowski, but otherwise have developed along independent lines.

Promoters of French rocketry have long been pressed for funds, and have had to work with only limited resources. Money is still short, but recent increases accorded both R&D and production have helped considerably. With what it has available, France has adapted and improved several German concepts and has advanced many new, original and brilliant solutions to their own problems. The crucial electronic industry has enjoyed a particularly spectacular advance in France, which has aided missile development.

With an eye on both economy and the European tactical and strategic picture, France has restricted her rocket programs to those she feels essential and within her means. Light industry has adapted well to the age of missiles. Heavy industry, on the other hand, experienced some difficulties in obtaining qualified personnel, particularly on the worker level. The situation there, however, has improved.

Industry and defense agencies have discovered that closer-than-normal cooperation has become necessary to properly develop the missile field. This has created consequent modifications in habitual French independence, causing some departure from traditional ways of business.

For both the military and the entrepreneur, the missile age has brought important changes in France, both organizationally and mentally. That the country is adapting well, however, seems evident.



Proximity-fuzed PARCA SAM leaves launcher.

Background to Developments

It is hard to tell just when French rocketry began. Before the first World War, Rene Lorin wrote of a reaction propelled rocket plane in the AEROPHILE, a concept later enlarged into book form, and in 1911 Dr. Andre Bing received an important rocket patent. During the war no other country save France employed rockets operationally. Both surface-to-air incendiary rockets and air-to-air *Le Prieur** types flown on *Nieuports* were used against German Zeppelins and captive balloons. There is also 1915's catapult-launched *Torpille aerienne,* which was a primitive, radio-gyro controlled flying bomb, a World War I V-1. This 1100-pound SSM could carry a 440-pound payload. The French also used 27 and 34 mm signal rockets from 1914 on.

In 1912 Robert Esnault-Pelterie spoke before the French Physical Society on rocketry and in 1927 gave his famed lecture to the French Astronomical Society on the subject "Exploration of the Very High Atmospheric Regions by Rockets and the Possibility of Interplanetary Travel." This was later enlarged and published as a book.

** Invented by Navy Lieutenant Vaisseau Y. le Prieur, Nieuport Scouts carried four rockets on each side. In one engagement in the spring of 1916 four enemy balloons were set afire by these early AAMs. See* LA CONQUETE DE L'ESPACE, *V. Coissac, Tours, 1916.*



French rocket-astronautical promoter-author Ananoff (right) at first IAF Congress.

During the 1930s Damblanc and others made important contributions to rocket literature. Damblanc, incidentally, was first to photograph multistage rocket separation. Esnault-Pelterie worked with the Armament Fabrication Technical Services at St. Cloud and, having developed a light alloy motor, made many experiments with gasoline-ether and liquid oxygen propellant combinations, starting in 1934. Firing took place at the French Army Proving Ground.

In 1937 an astronautical-rocket exposition took place at Paris' Palais de la Decouverte. Rocket-propelled bombs were studied by Rougeron and J. J. Barre who, with the aid of Arnould, Genty and Dubouloz, conducted a static test on the EA-41 rocket during 1941 under the noses of the Germans. I.M. Tercet tested small powder rockets. The EA-41 was unguided, fin-stabilized, and ten feet long. Immediately following V-E day, a 35-mile flight was made near Toulon in Southern France, at a maximum thrust of 2200 pounds for some 13 seconds firing time.

Rocket-Astronautical Activities

While rocket developments in Germany and America followed the growth of rocket and interplanetary societies, France's society movement seemed almost entirely apart.

In 1945 Ananoff and Monier created the Astronautics Section of the University Aero-Clubs Association of France. With an imposing list of technical and scientific advisors and an editorial staff, some progress was made and four issues of the journal L'ASTRONEF were published. But, by late 1947, the section was dissolved, and again French rocketry at the society level foundered.

Since 1955 everything has changed. Leading French scientists, engineers and military authorities have joined together to form the French Astronautical Society, and the BULLETIN D'ASTRONAUTIQUE, of much higher caliber than previous society publications, is now published. In December 1956 a great International Congress of Rockets and Guided Missiles was held in Paris, where experts gathered from all over the world. A full-fledged journal FUSEES ET RECHERCHE AERONAUTIQUE has been appearing quarterly since June 1956, often more than 100 pages in length, with technical and semitechnical articles by French and foreign experts.

French Missile Developments

French missiles can be divided into six categories or missions. These include air-to-air, air-to-surface, surface-to-air, surface-to-surface, drone and special test vehicles, and upper atmosphere sounding rockets. Rocket-powered, manned airplanes will not be considered in this article. For ease of reference, many details have been placed in the accompanying charts.

Air-to-Air Missiles

The Matra M.04 is produced by Sud-Aviation and the Society Matra. It is 2/3 scale model of a development missile that has surface-to-air and air-to-air applications. An SEPR 2750-pound thrust rocket motor supplies thrust for 14 seconds on liquid propellants. It has all-metal construction, duralumin skin, and gyro-controlled aerodynamic tail vanes and



'Veronique' liquid propellant engine firing.



SNCA du Nord's CT.10, a thoroughly proven target plane recoverable by parachute.

French Missile Arsenal

Designation	Contractors	Agency	Velocity	Range/ Altitude miles	Weight lb.	Length ft.	Diameter in.	Powerplant	Thrust lb.	Firing Time sec.	Remarks
Air-to-Air Missiles											
M(AA).20	MATRA	Air Force	Mach 1-2	1		15		liquid SEPR	2755	14	For use on Mystere A, B. In production.
M.04	MATRA	Air Force	1118 mph		1015	15'1"	16	liquid SEPR	2755	14	Tested on Voutour, Grognard. Can be parachute recovered. 245 lb. payload.
M(R).051	MATRA	Air Force	Mach 1.5		350	9'10½"		solid			Used on Mirage, Voutour. In production. Solid booster.
M.510	MATRA	Air Force	Mach 1.7		350	9'10"					
M.511	MATRA	Air Force									Secret. Reportedly for use on Trident.
AA.10	SFECMAS, SNCA-N	Air Force									
1524	Sud-Aviation	Air Force									Tested at Colomb-Bechar; successful in destroying drones.
550	Dassault	Air Force						Viper TJ			LPR booster by SEPR.
5103	SFECMAS, SNCA-N	Air Force	Mach 2	3-6½	287	8'2½"	10	solid			Flown on Meteors, Mysteres, Voutours. In production. In-line solid booster. 57 lb. payload.
Air-to-Surface Missiles											
BB-10		Air Force									Radio controlled bomb.
1522	Sud-Aviation	Air Force									Also air-to-air possibilities.
.....	.....	Air Force									Rascal-type rumored.
Surface-to-Air Missiles											
Maruca	SNECMA, DEFA	Navy									
Masalca	SNECMA, DEFA	Navy									
M.043	MATRA, SNCA-N							ramjet			SEPR solid booster.
PARCA	DEFA	Army	Mach 1.7	14	2200	14.7		liquid			Ramp-launched. Uses four solid boosters.
SA.100	Dassault										
SE.1524	Sud-Aviation										
SE.4100	Sud-Aviation		Mach 0.8	7½	287			liquid			A test rocket with solid in-line booster.
SE.4300	Sud-Aviation		near Mach 1	12	2200		18	liquid			A training, Nike-type missile, boosted, 11.1' span.
4400	Sud-Aviation										
422	MATRA										
.....	Sud-Aviation	Air Force						liquid			Presumably the ultimate development of Trident, possibly making it a Bomarc-type missile.
Surface-to-Surface Missiles											
BTZ-411.01	BTZ	Army									Coleopter-like, bazooka-type, two-stage missile.
ENTAC	DEFA	Army	190 mph	1.3				solid			Cable-guided, antitank missile. In production.
Jericho											
Lutin	BTZ		280 mph	3	33	4.25	16	ramjet			Rocket boosted.
Ogre I (BTZ-412.01)	BTZ		600 mph	50	720	6.5	36	ramjet			Photo-reconnaissance missile, liquid rocket boosted.
SE.4200	Sud-Aviation		Mach 1	60-70	660	10		ramjet			Ramp-launched. Accurate. In production. Has two solid boosters.
SE.4500	Sud-Aviation										
5200	SFECMAS	Army									AT missile, wire-guided, range 6500 ft.
SS.10 (5202, 03)	SFECMAS, SNCA-N	Army	190 mph	1.24	35	2'10"	6.3	solid			Antitank, close support rocket. Hollow charge. Very accurate, wire-guided. In service use.
SS.11 (5210)	SFECMAS, SNCA-N	Army	430 mph	2		4		solid			Improved, longer-range version of SS.10. In production. Solid in-line booster. SS.22 version rumored.
Miscellaneous Test Vehicles, Drones											
910	Breguet		500 mph					none			Unpowered glide bomb test vehicle.
CT.10 (Arsenal 5.501)	SNCA-N	Navy	280 mph	30	1452	19'8"		pulsejet	396		Launched from solid rocket boosted carriage. Can be parachute recovered. Target drone, radio guided.
CT.20 (T. 5.510)	SNCA-N	Navy	560 mph	125	1444	17'8"	25	turbojet	880		Guided target drone. Flight time is 45 min. Can be controlled within flight path of ±1.6 ft., and can be landed with 0.6 mile circle.
ECA.20	ECA										Guidance test vehicle.
ECA.26	ECA										Guidance and control test vehicle.
ECA.27	ECA										Test vehicle, airplane structure.
EOLE.51	DEFA										
"Reduced Version"				35	3943	24.4	31.5	liquid rocket	22,820	18.7	See text.
"Normal Version"				125	7497	36.1	31.5	liquid rocket	22,490	45.3	See text.
OPD.320S	ONERA			(100:payload)							Two-stage telementary test vehicle.
S.T. 450	SFECMAS, SNCA-N		Mach 1					ramjet			Parachute recoverable. Two solid boosters.
.....	Turck										Guidance test vehicle.
Upper Atmosphere Research Missiles											
Monica-4 (ATEF-14)	ATEF	Air Force	3100 mph	60	271	16'10"	6¼	solid		25	Four models available.
Veronique (Type NA)	DEFA	Ministry National Defense	3200	84	3180	24	20	liquid rocket	8820	45	Record altitude for European rocket. See text.

hold everything!



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is considered highly successful. Tests have been made at Sahara ranges since 1952, with aircraft like the *Grognard* and *Vautour* having fired it operationally. (It can be parachute-recovered.)

Matra production missiles include the AA.20 and the R.051, the former being liquid propelled, the latter solid powered. The M(AA).20 is carried by the *Mystère A* and *B* fighters, and is thought to be very accurate. The R.051 is a beam rider, incorporates a proximity fuse, is highly accurate, and features canard construction. It, too, arms the *Mystère*. Range is classified, but is believed to be considerable. M.510 has an optical guidance system and is a two-stage affair. M.511 may be used on the *Trident* rocket-powered airplane.

Another program pushed by L'Armée de l'Air is the SFECMAS 5103, built by Nord. Like the R.051, it incorporates a warhead effective over "plusieurs mètres de distance," armed by proximity fuse. It has a cruciform airfoil and is probably a beam-rider. With both a solid sustainer rocket and in-line solid booster, it flies with constant velocity from the time of booster *cutoff; Super-Mystères, Meteors* and *Vautours* are known to have fired it. Little is said about Sud Aviation's 1524 except that it is a development sponsored by L'Armée de l'Air and has been tested successfully. It is possible that the ASM 1522 development also has an air-to-air rôle.

Air-to-Surface Missiles

This is one category of missiles that the French apparently have not investigated thoroughly or at least, little knowledge of their work has been released. Some of their air-to-air missiles can double as ASMs, and such short-range surface-to-surface rockets as the SS.10 are fired from helicopters at low altitudes. The French Navy is now building a helicopter carrier that will not only be outfitted with defensive missiles but will have its helicopters armed with offensive varieties.

The BB.10 represents the latest of a series of guided bombs developed since the war and is used with the *Vautour* fighter-bomber. It features cruciform fins, an annular shroud wing and canard surfaces. The SNCASE (now Sud-Aviation) 1522 is a development about which nothing is known and it may not have been carried forward into operational use. France is rumored to have a *Rascal*-type ASM, but substantiating information is not available.

In effect, then, the French air-to-surface missile picture seems to show the use of small, high velocity rockets adapted from air-to-air use (a good example being SNEB rockets launched from Matra-type 116 pods carried by the *Vautour*), guided bombs, and, if you consider helicopters, SSMs launched from low-altitude platforms.



Later version of the SNCA du Nord CT.10, this CT.20 has greater speed than its predecessor, has been sold in quantity to foreign countries, notably Britain.

Surface-to-Air Missiles

French surface-to-air missiles are designed to fit in between classic air defense ground setups and the intercepter. Most models are in the tactical experimental stage. The leading types are the Sud-Est (now Sud-Aviation) 4300 and LRBA-DEFA's *PARCA*, which stands for Projectile Autopropulse Radioguidé Contre Avion.

Sud's 4100 is a liquid-sustained, solid-boosted experimental type which led into the 4300. Nothing concrete has been given out on the Navy's *Masalca* and *Maruca*.

PARCA has a range of about 12 miles, perhaps 14 at the most, and can bring down a plane flying at an altitude of six miles. It is a beam rider, and the warhead is detonated by proximity fuse. *PARCA* was developed with the aid of LRBA at Vernon, EET-V, l'Atelier de Constructions, Puteaux and EET-B which handled test firings in both France and Colomb-Bechar. Cruciform canard controls are featured with delta fins. The French say little more about 4300 save that its performance is "sensiblement anologue" to that of the American *Nike*, is cruciform type, with no tail, and 45° sweep back. Thrust from its liquid rocket can be regulated. It is now used to train Army guided-missile personnel.

The possible eventual use of the *Trident* rocket-powered airplane as a SAM will not be discussed here, but reserved for a later article devoted to the rocket airplane.

Surface-to-Surface Missiles

Most significant French SSM research has centered on the antitank weapon, with notable success. Both the Army and Air Force have participated in these developments, the latter being interested in the helicopter-to-ground versions as noted earlier.

Within the SS.10 program are the SFECMAS 5200 (Nord) series* and DEFA's *Entac*, both with nearly identical ranges and velocities. They are wire guided, solid propelled, and have shaped charges able to pierce thick tank skins. The 5200 saw action in the Israeli war against Egypt with good results. Commands are relayed along wires, which unwind under the wings. The *Entac* version is now entering production.

SS.10 is highly accurate and needs only a few men for effective operation. Tests made in Colomb-Bechar, North Africa, have been described as 98 per cent accurate. The American Army has adapted the design to its own use.

The French have fired this missile from their SO.1221 *Djinn* and *Alouette* helicopters. Normally, three are carried on a launcher on each side. They have also reportedly been fired from the Dassault 315 *Flament* twin-engined transport and from the Potez 75 tactical support airplane.

The SS.11 (SFECMAS 5210) program is a longer-range version of SS.10 and is under large-scale production for the Army and Air Force. Other than surface-to-surface and air-

** The 5202 is the training version, and 5203 is the operational version.*

to-surface applications, it may be tried out in an air-to-air role. Solid-propelled, an eventual ramjet version is rumored.

Other French SSM projects include Zborowski's BTZ-411.01 bazooka-type missile, his 33 pound *Lutin* army infantry ramjet and the *Ogre 1* long-range photo-reconnaissance ramjet, with liquid rocket booster. This latter is tailless, with barrel-type coleopter rings.

The only moderate-range vehicle known to be under development in France is the SE.4200, which was originally developed by SNCASE (now Sud-Aviation) under the direction of the Direction Technique et Industrielle de l'Aéronautique. Army's Section Technique later tested it and brought it into service. Designed to carry a powerful charge to distances of 60 or more miles, it is launched from a truck-mounted ramp by a solid booster (which drops upon cut-off).

The charge is carried beneath the missile in a pod. It is gyro-stabilized, attitude being maintained by wing-tip controls and elevons. An altimetric device controls altitude. It is hoped that this tailless guided missile will graually replace long-range artillery. There are only rumors of longer-range SSMs under development in France.

There are a number of experimental. test vehicles in France as well as several drones. The Breguet 910 is an unpowered glide bomb which is released from an airplane at 15,000 feet, to glide to the target at subsonic speeds.

This is unusual in that it has prestressed concrete wings. ONERA of Châtillon developed an OPD.320S experimental telemetry test rocket which could carry up to 100 pounds of parachute-recoverable instrumentation. SNCA du Nord has a CT.10 (ARS 5.501) guided target plane that has been thoroughly tested and used, plus an advanced CT.20, both recoverable by parachute. The former uses an Arsenal pulsejet, gives 396 pounds of thrust, and has seen service with the French and British navies. Ramp-launched by two powder rockets on a carriage (recovered after separation by parachute), it is radio controlled and has an auto-pilot.

Should the CT.10 fall in the water, it will float until pickup and, like the *Skokee*, it has a spike in the nose for land recovery. The French use it for antiaircraft artillery and surface-to-air missle training. CT.20 is much like the .10, has a turbojet engine, and is considerably faster. Both have been sold abroad, notably to the British. The Eole-51 was an experimental, fin-stabilized rocket used by DEFA as a test vehicle for *Veronique*. Operating on liquid oxygen and alcohol, it featured sheet-metal construction. The Société SAGEM constructed the missile, and two were fired by CIEES, Colomb-Bechar, in 1952.

ECA. 20, 26 and 27 are all guidance and control test vehicles. The SFECMAS-Nord ST.450 is ramjet powered, solid rocket boosted, and can be parachute recovered.

Atmospheric Sounding Rockets

France has two entries in this field, the *Monica* ATEF-14 and the *Veronique*. The former comprises a series of two- or three-stage solid-propelled rockets, and was named for the daughter of an engineer who worked on the missile. (She was born on the day of the first firing.) It is a low-cost rocket, and, depending on the type and payload, can fly from 55 to 90 miles high. Backed by the Ministère de l'Air, some 15 are expected to be fired during the 1957 part of the International Geophysical Year. Experiments involving cosmic ray and atmospheric physics are performed by *Monica*. A 4-6 channel, AM/FM telemetering system is used.

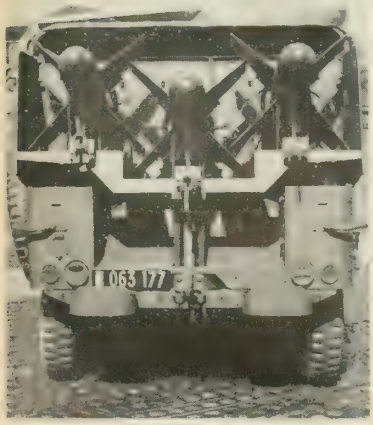
The *Veronique* holds, as far as is known, the European altitude record of 84 miles, established with rocket NA-14 in February 1954. The missile has variously operated with WFNA and diesel oil or furfuryl alcohol or oil of turpentine, the last being used in the record performance. DEFA, through LRBA, developed *Veronique* in 1949, and it is still undergoing development and modification at the Vernon facility.

Probably the most unique feature of *Veronique* is its intitial stabilization system, which consists of four unwinding cables extending from outriggers attached to the missile. When speed and altitude have been gained, the outriggers are explosively detached, and *Veronique* continues upward, now stabilized by her aerodynamic surfaces.

The first vehicles were fired in 1950, and since that time a number of changes have been introduced.

Veronique's telemetering system can transmit 20 measurements; carrier frequency is 152 m/c; time modulation is converted at the surface station to amplitude modulation; and some 35 information bits can be transmitted per second

New *Veroniques*, the first since 1954, are now being constructed, and by the time this article is printed the first may be ready. Difficulties with the telemetering system, however, may prevent firings until late in the year or early 1958. ★



The outstanding antitank missile, SS.10.



International editor for m/r, Anthony Vandyk, examines instrumentation package in Paris.

SWEDEN . . .

From Torpedoes to Antiaircraft Missiles

by Frank McGuire

THE MAIN EMPHASIS in Sweden's missile program appears to be on SAMs and missiles for coastal defense. Work has been underway on other types for some time, but not with the high priority placed on aircraft-interceptor missiles in the *Bomarc* and *Nike* classes. Surface-to-surface missiles for naval use have been under study, but application of these to land operations has not been pushed.

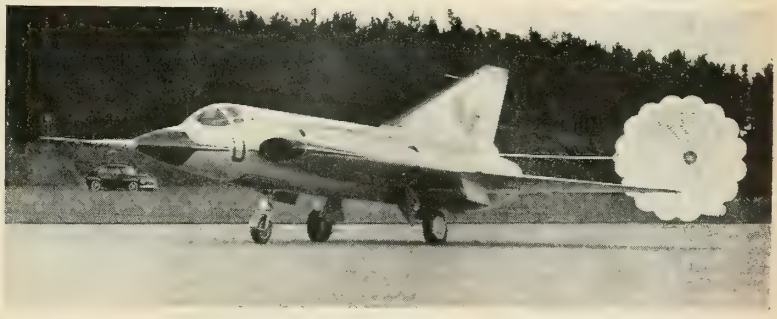
Since 1955 the Swedish Air Force has had under development an interceptor known as *Luftforsvarsrobot,* which is of the *Bomarc* class and capable of very high altitude interception at ranges from 120-150 miles. Other, smaller, missiles are also being developed for antiaircraft defense and some are undoubtedly operational.

Sweden's total missile industry activity includes many areas, but not ICBMs, and puts little dependence on foreign production. An exception to this, however, is the September purchase of ten *Jindiviks* from Australia. Another type drone is being produced by A. B. Flygmal Co.

Bofors has developed a guided AAM for use on the J35 interceptor. The Saab A32 *Lansen* all-weather attack aircraft is also equipped to handle Swedish-developed AGM for tactical strikes. One of these aircraft rockets is the *Jaktrobot* (fighter missile), which is due to become operational soon, as is the *Sjorobot* (sea missile) for naval surface-to-surface use.

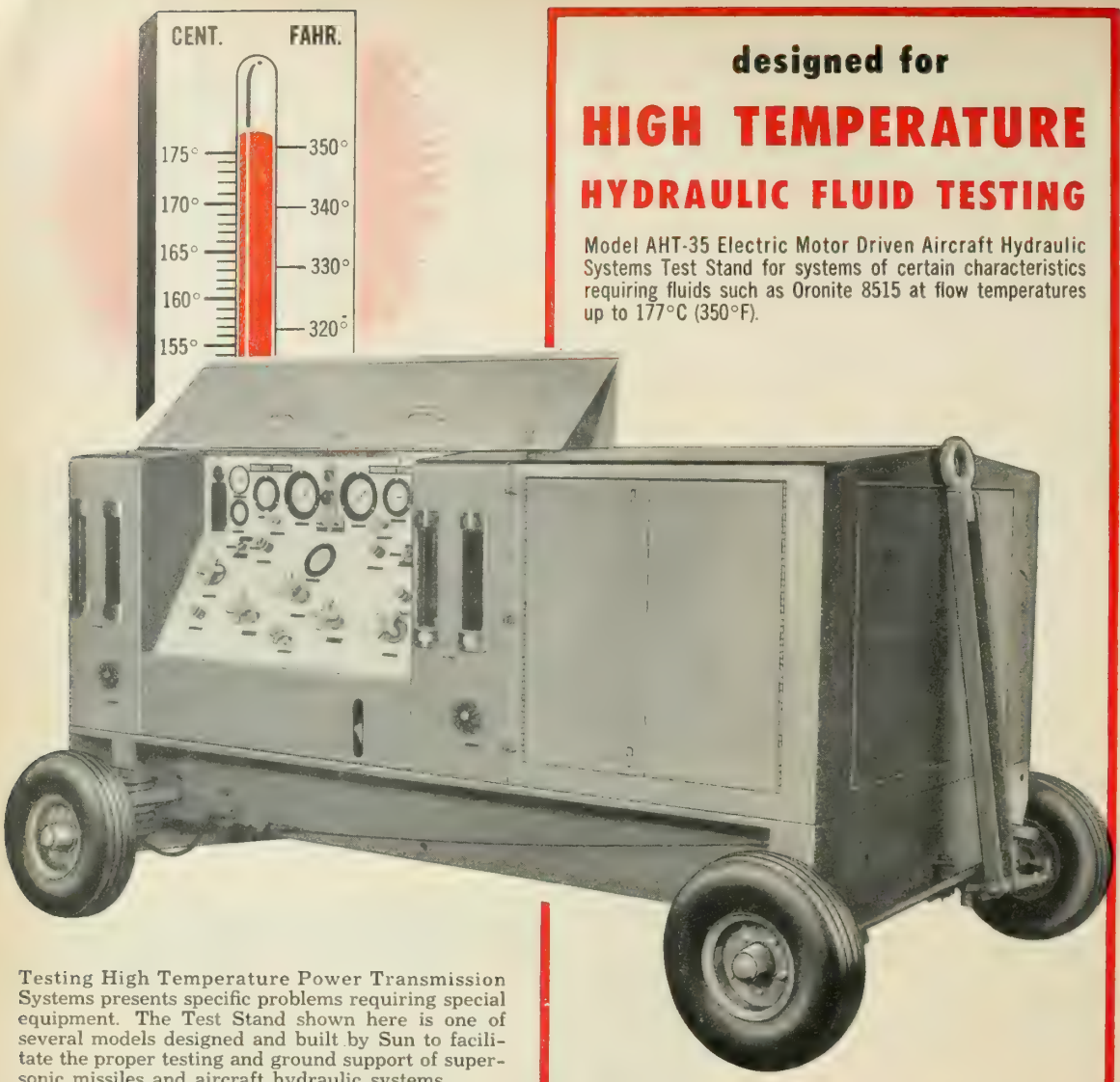
The Swedish missile industry is also pushing research on ramjets, high-energy fuels and advanced rocket designs. Their propellant materials production is quite adequate for supplying the blossoming missile program. ✶







Swedish army troops (top) will be supported by tactical missiles like those fired from the SAAB DRAGON, J35 (center). The latest torpedo boat design, the T101, may be equipped with missiles and guided torpedoes.



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JAPAN . . .

From Research Rockets to Missiles for a New Army?

By Frederick I. Ordway III

JAPAN IS WORKING hard to enter the forefront of missile and space-flight sciences. Activities center around three main areas of endeavor: (1) military rocketry, (2) research rocketry, (3) space flight planning.

Tokyo newspapers have made much of recent Japanese efforts to provide the country with adequate missile defenses. The Japan Defense Agency is hoping to legislate a defense secrets preservation law which will permit full production of guided missiles in Japan under license from foreign countries.

Japanese authorities point out that *Nike* and other American types could be employed if there were an adequate security protection system in their country. The government is not, however, limiting its considerations to American rockets, and has expressed interest in Italian (Polverifici Stracchini, S.A. will supply 500 Airone AAMs) and Swiss developments.

The Mitsubishi Electric Machinery Co. has concluded an arrangement with Switzerland's Oerlikon Machine Tool Works Buehre & Cie, whereby Japan will receive patent rights to produce the *Oerlikon-56* SAM and launcher. The contract covers an agreement with Contraves AG of Zurich, an Oerlikon affiliate, which produces missiles and fire control equipment. This has been done under the current equipment modernization program, and should provide Japan with some missile defense by 1959.

If Mitsubishi gets permission from Japan's Foreign Exchange Commission, it will pay 18-million yen (half a million dollars) for patent rights. Oerlikon wants eight per cent patent rights for the *-56* and five per cent of sales of launching and fire control equipment.

Sources close to the Defense Agency believe that during the next few months Japan will purchase a complete *Oerlikon-56* rocket launcher setup for the purpose of making careful studies of the system. Mitsubishi Electric, Mitsubishi Shipbuilding and Engineering, Mitsubishi Heavy Industries, and Mitsubishi Chemical Industries will cooperate in the Japanese missile program.

It is interesting to note that Yasjiro Okano, the liquidator of the old Mitsubishi Heavy Industry Co., has been named chief of the Guided Missiles Council, which effects liaison between industry and government.

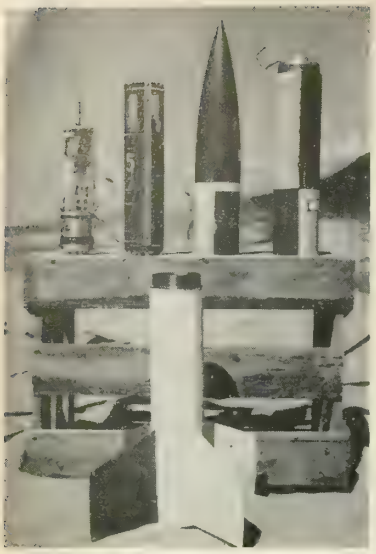
Pilot production of the first Japanese guided-AAM is expected to get under way by 1959. The missile will be in the *Sparrow* class. By 1960, the Japanese expect to begin production of a *Nike*-type missile for ground-to-air use. The model TMB-0, a radio-controlled test missile, was cancelled after two unsuccessful tests. The TMB-0 was 5'4" long, with a swept-wing span of almost 3 feet. Launching speed was about 410 fps.



Missiles will change Japan's self-defense force.

Research Rocketry

Recent attention has been given to Japanese rocket research (m/r Oct. 1956; JET PROPULSION, March 1957).





The Japan *Rockoon* Committee, in a meeting at Ritkyo University, announced that 30 balloon-launched rockets will be fired during the I.G.Y. They will be released for cosmic ray, ionospheric, and solar radiation research. Three of these will probably be fired from the ship *Ryofu Maru* in the Pacific in August. Besides *Rockoons*, Japan will fire 50 additional I.G.Y. rockets. Some of the pre-I.G.Y. Japanese *Rockoon* tests have been successful. The first left the *Ryofu Maru*, located off the Boso Peninsula (Chiba, Japan) in April, but failed completely.

The second, however, was successful. Eight rubber balloons, each filled with 800 grams of hydrogen, lifted the 3.95-foot-long rocket at a velocity of 985 feet/sec. Firing took place at 65,500 feet, and the rocket reached a peak about 50 miles west of the launching ship. Longer *Sigma*-type rockets will also be used to reach up to about 68 miles.

Japan's surface-launched research missiles include the *Kappa-3* and *Kappa-4*, and *Kappa-5*, two- and three-stage vehicles, respectively. Firings have taken place from Michikawa Beach, where the Tokyo University Rocket Research Center has a test facility. Launched at an angle, *Kappa-3s* have a top speed of Mach 3.7, a firing time of 143 seconds and a range of about 20 miles.

A successful Japanese *Rockoon* test was made at Tateno, near Tsuchiura, Ibaragi-ken, in which cosmic ray experiments were carried out. This rocket was 3.94 feet long, and carried both a Geiger counter and a telemetering device. *Kappa 3* successfully fired at Michikawa Beach, soaring to about 15 miles. It was 16 feet long, and weighed 320 pounds. It was sponsored by Tokyo University.

Kappa-5s, which will be fired in support of the I.G.Y. in October of this year, reach about 80 miles. An intermediate rocket, *Kappa-4*, is 16 feet long and can attain Mach 5 velocities, soaring to some 40 miles.

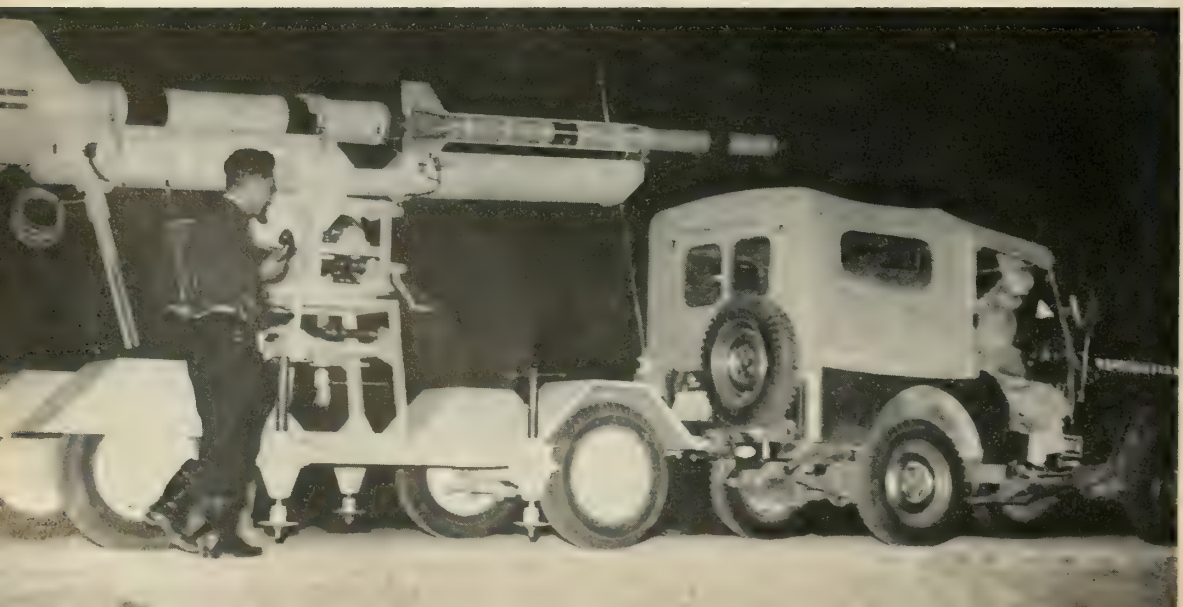
It has been announced that Japan will buy, in addition to its own rockets, five U.S. *WASP*-type rockets to be launched from balloons.

Space Flight

That the Japanese are astronautically minded was made clear by F. C. Durant (m r, Oct. 1956 and Nov. 1956) last fall. The YOMIURI JAPAN NEWS (Tokyo) advises taking off for Mars if (1) life is getting you down and (2) you don't know what to do with the extra money you have in your pockets because of income tax cuts. Sensitive to atomic bombs, the paper goes on to point out an advantage of Mars: ". . . the air (if there is any air) is not already contaminated by radioactive fallout."

In a more serious vein, the Japanese scientists are taking a long look at earth satellite plans. The head of Tokyo Astronomical Observatory and of the Japanese Chapter, Earth Satellite Committee, has recently toured America and Europe and has announced that Japan would be provided with a Schmidt astronomical camera for satellite observations. Earth satellite observation units have been practicing regularly, and feel they are ready to do their part in the world-wide observation program. ★

Left above—Basic components of BABY TELEMETER, early Japanese research rocket. Left—BABY RECOVERY rocket leaves launcher. Below—KAPPA research rocket on launcher-carrier.



ITALY . . .

NATO Missile Effort Off to Slow Start

By Franco Fiorio

IN THE 12 YEARS since the end to World War II, there has been a lot of interest in Italy in the rocket field, by individuals, government and private research groups. Unfortunately, both lack of funds and a coordinated effort by industry, in addition to the absence of a clearcut government program, have resulted in a serious delay in developing the Italian potential in rocketry.

The top government agency in charge of rocket development is the CORAMI (Comitaye Razzi & Missile), a joint group headed by Air Force Lt. Gen. Casero and working directly under the Chairman of the Italian General Staff, Gen. G. Mancinelli. CORAMI, in addition to its planning and programming activities, coordinates the rocket research and development effort of the three services and regulates the use of the new defense rocket and missile test range.

Military security is clamped tight on the research and testing work on the new test range, operated by the Italian Air Force.

Three civilian agencies are also involved in rocket development: SISPRE (Societa Italiana Studio Propulsione a Reazione), a research and production group sponsored jointly by the Italian Dept. of Defense, the Fiat, Finmeccanica and Bombrini-Parodi companies. Former Air Force Chief of Staff, Gen. A. Urbani, ret., is president and general manager is Professor Ing. Matteini, an electronic specialist.

The SISPRE group is looked upon as a potential link between the government and industry for the development of future weapon systems, in a role similar to that of Ramo-Woolridge in the U.S.A.

AIR (Associazione Italiana Razzi) is the Italian Rocket Society, active in the theoretical field and functioning as a representative of the profession. President is Professor Gen. G. A. Crocco and executive Vice President is Dr. A. Eula, Professor of Aerodynamics at the University of Rome.

CAAI (Centro Aeronautica & Atomico Italiano) is a private, nonprofit organization, sponsored by a group of members (260) of the Italian Parliament, by industry leaders, members of the government and independent scientists. It attempts to disseminate basic information on aviation and nuclear matters and to trigger an increase of interest and activity in the studies and production of advanced air vehicles, among them, rockets and missiles. President is the Hon. F. A. Di Bella, Congressman from Sicily; acting Secretary is Dr. G. Partel.

Research and Development

Several companies and private groups are active today in rocket research and development. There is a substantial number of engineers working on individual ideas, but here again lack of funds and coordination are the main obstacles to the achievement of practical results.



The following are some of the most important research groups:

CESPRE (Centro Studi Propulsione a Reazione) is the research branch of SISPRE headed by Gen. Urbani. This group is by far the most important in Italy and is now working on the air-to-air infrared solid-propellant missile C-7 and other classified projects.

Contraves Italiana is the Italian subsidiary of the Swiss company by the same name, which is part of the Oerlikon group. This company is developing a later model of the surface-to-air liquid-propellant missile, well known in the U.S. where it was introduced some years ago by Oerlikon Co.

BPD (Bombrini Parodi Delfino) is the largest Italian manufacturer of ammunition, explosives, and propellants, producer of the standard solid-propellant (bibase-ballistite type-M7) used by the Italian services. BPD is now conducting classified research in the field of solid propellants of improved characteristics.

Stacchini Co., formerly a producer of TNT charges for aircraft bombs, has entered the rocket area, in cooperation with Italjet. In the past years it has developed a family of unguided rockets of many types, powered by the standard BPD bibase solid propellant. None of these went beyond the testing stage. Only exception is the order from Japan for the *Airone* rocket, a cheap, solid-propellant (BPD) surface-to-surface unguided missile. Range of the *Airone* is reported to be over six miles. No other data are available. In addition to this activity, the Stacchini Co. has also sponsored research work on experimental rockets designed by Prof. Salvadori of the University of Rome.

Contin Co. is a small activity beyond the outskirts of Rome engaged in an experimental project on a small liquid-propelled research rocket. The



Globe Aerostatique . . . 1783

Montgolfier's vanguard project

A sheep, a duck, a rooster—the first payload carried aloft for atmospheric research. Louis XVI, his queen and his court, were astonished witnesses as Joseph Montgolfier's smoke-filled balloon rose in majesty 1500 feet over Versailles. The passengers? unharmed (except the rooster, kicked by the sheep).

Project Vanguard, 1957, is an equally momentous "first"—an attempt to place a 21-pound satellite in an orbit 300 miles up. Aerojet-General, designer-builder of the famed Aerobee-Hi, will supply vital second-stage propulsion systems for Vanguard launchings during the International Geophysical Year.

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rocket was designed by Dr. Sivori of the University of Rome, under the supervision of Italy's leader in Italian rocketry, Gen. Prof. G. A. Crocco.

Motofides S.p.a. in Livorno, part of the Fiat group and manufacturer of torpedoes for the Italian Navy, has been sponsoring a research project headed by Dr. Ing. A. Robotti. The project has designed a series of liquid-propelled, surface-to-air rockets of clean configuration and fair characteristics. The propellant is nitric acid and aniline. Design emphasizes low production costs and ease of maintenance and operation. An experimental order for an undisclosed number of *Robotti* unguided rockets and launchers has been awarded to Motofides by the Armed Forces. Diameter of the rocket is 40-50 in. and the length 15-16 ft. Speed is supersonic.

Boscari Co., headed by Dr. Ing. F. Salvini, one of the little known but outstanding pioneers of the Italian rocketry, boasts several interesting developments. Among them is a patented new type of multibase solid propellant, designated S-I, with excellent stability, low hygroscopic sensitivity and high shock resistance. Its low combustion pressure (1/3 of the ballistite type propellant's pressure, at equal volume and temperature) affords substantial savings in the structural weight of the combustion chambers.

Other Boscari developments include an underwater fishing rocket gun and a fragmentless plastic Bazooka practice head, capable of registering hits in color on the target. In cooperation with the Hispano Suiza Co. and the Italian Industrie Meccaniche Napolitane (INM), the Boscari Co. has developed a *Katyuscia* type of multibarrel (20) rocket, designated HSS-R 80/100, which has since been adopted by the Dutch and Egyptian Armies.

Production Facilities

Only a handful of firms are currently producing rockets in Italy on a mass production basis.

BPD (Bombrine Parodi Delfino) makes *Scar* 2:75-in. airborne practice rockets for the services. Boscari is subcontractor for the practice head.

Boscari makes standard bazooka practice rockets with plastic heads for the Italian Army. Subcontractor for the solid propellant is BPD.

Italjet, a group formed by the Stacchini, Motofides and Aerojet-General, make JATO units for NATO offshore requirements.

Despite this token activity, there are several indications, including a renewed interest by the Italian Defense Ministry, that the rocket business will increase substantially within the next few years in Italy, both in the research and in the production fields. ★



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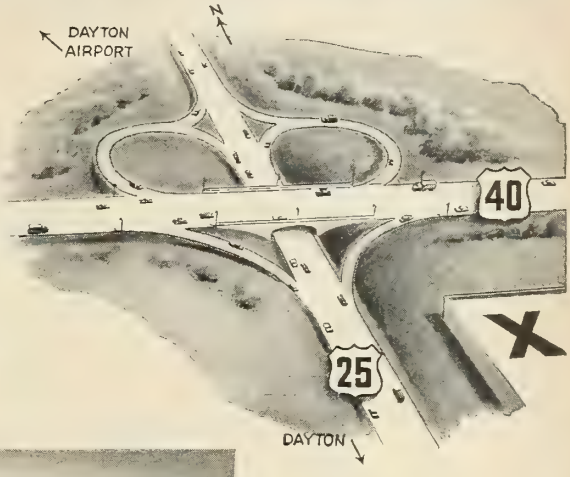
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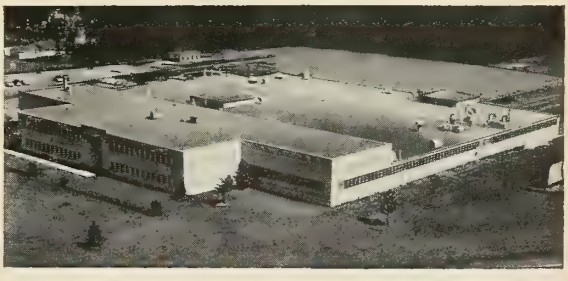


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Foreign Surface-To-Air Missiles

MISSILE		Code	Date	Maker	LENGTH (feet) Missile	Booster	Total	DIAMETER body, average (inches)	SPAN wing or t max. (fe
	(E)	AWA		1	17.6				
	(E)	AWSG		1, 2					
Bloodhound	(E)			34	15.0*			15.7*	5.3
Bobbin	(E)			34					
Bomarc	(US)	IM-99	1952	3, 32, 35, 40	47			36.0	18.2
British SAR 2"	(E)		1937						
British SAR 3"	(E)	UP	1938		4.0				
British SAR 5"	(E)				6.0				
British SAP	(E)		1916	36					
EE Guided Rocket	(E)		1954	37					
Enzian	(G)	E4	1944	5	31	7.0	31.0	7.	33.
Enzian	(G)	E5	1944	5					
Feuerlilie	(G)	25	1941	6	4.16	3.		7.	2.9
Feuerlilie	(G)	55	1943	6	15.75			21.6	7.3
Funryu	(J)	Model 4			13.1			23.6	5.2
Gapa (rocket)	(US)	A	1945	3	10.	6.4	16.4	12.0	2.4
Gapa (rocket)	(US)	B		3	19.	8.0	27.0		
Gapa (ramjet)	(US)		1948	3	26.			12.0	
Hawk	(US)		1956	7, 21, 39	16.3			14.0	4.9
Hecht	(G)		1941	6	6.5			9.9	2.5
Japanese SAR	(J)	A	1944						
Japanese SAR	(J)	B	1944						
Japanese SAR	(J)	C	1944					4.73	
Lark	(US)	XSAM-N-2	1949	8, 9	14.0	4.0		18.0	6.
Little Joe	(US)	KAN-1 & KAN-2	1944	10	11.34			22.7	7.
Loki	(US)		1949	11, 12				2.99	
Lop-Gap	(E)	A			14.0			9.5	2.
	(F)	M.04†	1949	13	15.0			16.0	5.
	(R)	M-1	1947		15.0			22.0	14.
Maruca	(F)		1956	14					
Masalca	(F)		1956	14					
Matra	(F)	M.04?†		13					
	(S)	MX-1868	1954	15	16.0			40.8	4.
Nike-Ajax (A)	(US)	SAMA-7	1950	9, 16, 17, 35	20.0			12.0	5.
Nike-Hercules (B)	(US)	SAMA-25	1954	9, 16, 33, 35	25.0			25.0	
Nike-Zeus (II)	(US)		1956	9, 16, 17					
Oerlikon SAR	(S)		1953	15					
Oerlikon	(S)		1950	15	16.5			15.0	
Oerlikon	(S)	54	1954	15	19.7			15.6	4.
Orione SAR	(I)		1956?	18	6.0			3.25	15.
Parca	(F)		1956?	19					5.
Rheintochter	(G)	R-1	1944	6	13.2	7.5	20.7	21.6	9
Rheintochter	(G)	R-3	1944	6.20	16.4	4.2	20.6	21.6	10
Rheintochter	(G)	R-3F	1944	6					
Russian SAR	(R)		1954						
Schmetterling	(G)	Hs-117	1944	22, 23	12.5	8.0		14.0	6
	(F)	SE-1524	1955	24					
	(F)	SE-4100	1956	24					
	(F)	SE-4300*	1956	24	13.5	11.2	24.7†	25.7	11
Sea Slug	(E)		1955		19.5			20.0	
	(R)	T-7	1955		23.0			25.0	
Taifun (Willy Ley)	(G)	F	1944		6.4			3.92	
Taifun (Gatland)	(G)	F	1944		6.28			3.94	
Talos (ramjet)	(US)	XSAM-N-6	1952	10, 11, 25, 26	15.0	10.0	25.0	18.0	4
Tartar	(US)		1954	27, 42	9.75	10.5	20.25	9.0	3
Terrier	(US)	SAM-N-7	1951	4, 27, 38, 41	13.0	14.0	27.0	12.0	4
Thiamat	(US)	MX-570	1946	28	14.3				
Thunderbird	(E)		1957	37	20.0*	6.0	20.0	24.0*	6
TMA-O-AC	(J)		1956						
US Anti-Missile Missile	(US)		1956	9, 27, 29					8
Wasserfall	(G)	C2-E2	1942	30	25.7			33.6	
Window SAR	(US)		1943		4.45			3.5	
Wizard (project)	(US)		1943?	31					
Z-Battery SAR	(E)		1943		6.0			4.0	

Conversion Data on the Manufacturer's Column in the Table of Surface-to-Air Missiles

No.	Maker
1	Armstrong-Whitworth
2	Sperry Gyroscope
3	Boeing
4	Reeves Instrument
5	Messerschmitt
6	Rheinmetall-Borsig
7	Raytheon
8	Fairchild Aircraft
9	Bell Telephone Labs
10	McDonnell Aircraft
11	Bendix Aviation
12	Grand Central Rocket
13	MATRA
14	SNECMA
15	Oerlikon
16	Douglas
17	Bell Aircraft
18	Polverfici Giovanni Stacchini
19	DEFA
20	Konrad
21	Northrop
22	Henschel
23	Bavarian Motor Works
24	SNCASE
25	Johns Hopkins University
26	Farnsworth
27	Convair
28	NACA
29	North American
30	Peenemünde
31	U of Michigan
32	Marquardt
33	Western Electric
34	Bristol Aircraft Ltd.
35	Aerojet-General
36	RFC Experimental W
37	English Electric Co.
38	Northern Ordnance,
39	Thiokol
40	Westinghouse
41	Kellogg
42	Allegheny Ballistics

tential — Experimental — Actual

WEIGHT (pounds) le	Booster	Payload	CEILING (feet)	RANGE (miles)	VELOCITY	THRUST (pounds) Missile	Booster	BURNING TIME (sec) Missile-Booster		GUIDANCE TYPE	PROPELLANTS Fuel	Oxidizer
				20								
										SRH		
0	6,500		80,000	200+	Mach 2.5+					RC, RH		
0											Cordite	
0				4.								
			50,000		Mach 2.0					BR		
0	794	1,050	47,600	16-24	920 mph	4,400	3,300	70	7	RC	Visol	HNO_3
		550				5,500		56			Gasoline	HNO_3
5	38.6					1,100		6		RC	Diglycol Dinitrate	
3			26,400	4.5	1020 mph	2,200	4,400	25	6		Alcohol	LOX
0		440	82,000	18.0	Mach .9	3,300		60		RC	Hydrazine Methonal	Peroxide
0		200			Mach 2.5					H		
			"Stratosphere"	22.0						RC		
0					677 mph	130		25		RC	Peroxide	
5.4		4						0.37				
3.2		2.2						0.37				
2.6		7.5		1.0				0.90				
0				10.0	Subsonic		1,000			RC, SRH	Aniline	RFNA
		100.0	10,560	2.0	410 mph		1,000			RC		
			100,000					0.8				
					1,000 mph	1,000		25.0	4		Methanol	LOX
0					1,100 mph	2,750		14.0				
0	1,850.0		47,600		Mach 1.3	3,400	3,275	30.0	15.0		Hydrazine	Peroxide
5			66,000	12.0	850 mph	2,200				BR		
0		300.0	47,500	25.0	1,500 mph	2,600		35.0		RC, SRH	Analine	HNO_3
				50.0	2,200 mph					RC		
			31,700	2.5								
0		44	66,000	12.5	1,705 mph					BR	Paraffine oil	HNO_3
2			60,000	15.5		2,200		30.0		BR	Kerosene	HNO_3
0			65,000							RC		
0	902.0	235	21,150	24.0	810 mph	8,800	165,000	10.0	.6	RC	diglycol	HNO_3?
0	970.0	350?	42,300		922 mph	3,900	62,000	45.0	.9	RC	Visol	HNO_3
						4,500				RC		
				37.5		17,000						
0	200	55	47,600	20.0	470 mph	840	750	30.0	4.0	RC	Tonka	HNO_3
										RC		
			39,400		Mach 0.8							
0			65,000		Subsonic							
0			60,000			17,600		40.0			amine	HNO_3
		40	47,600	7.5		3,200		3.0			butyl ether	acid
.6			52,800			1,850		2.5			cordite	
			75,000	40.0	Mach 4.0					BR, RH		
			75,000	15.0	Mach 2.5	1,000				BR		
					620 mph	200	7,200	45.0	3.5	H		
			13,000									
			47,600	31.0		17,160		45.0		BR	analine	HNO_3
			5,400	.51	1160 mph							
.0		20	2,115					4.0				

Legend

e: estimated (by photo measurement and calculation)
†: without spike
‡: is reportedly an SAM with booster attached
IM: interceptor missile
UP: unrotating projectile
XSAM: experimental surface-to-air missile
(E): England
(US): United States
(G): Germany
(J): Japan
(F): France
(R): Russia
(S): Switzerland
(I): Italy
SRH: semiactive radar homing
RC: radio command
RH: radar homing
BR: beam rider
H: homing
RFNA: red fuming nitric acid
SAR: surface-to-air rocket (unguided)
SAP: surface-to-air plane (radio drone designed to ram Zeppelins)
EE: English Electric

Another CEC first...

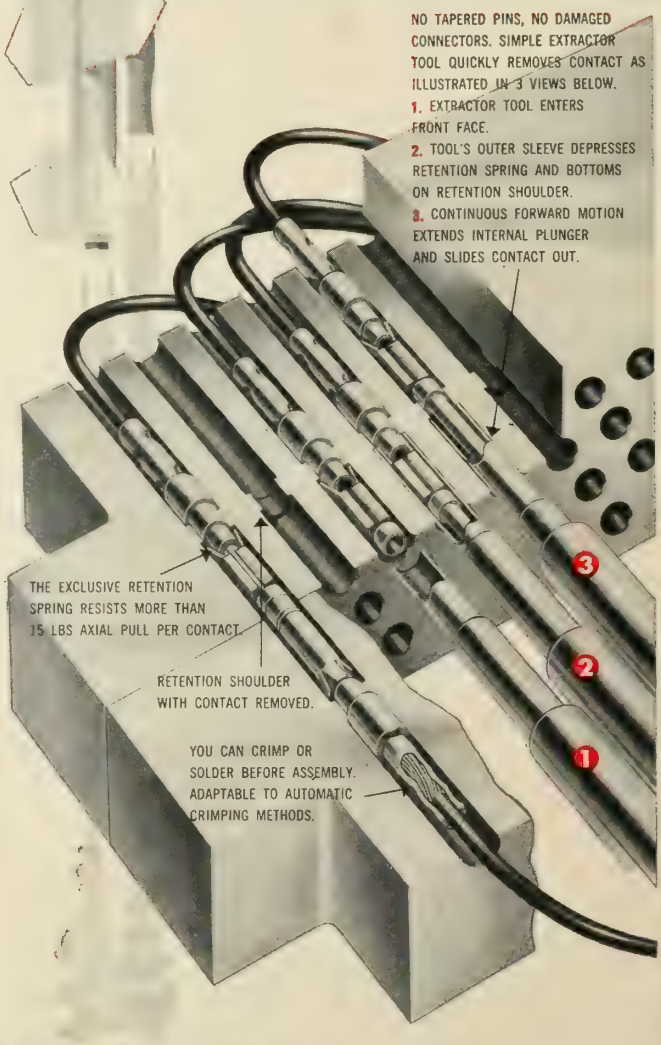
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Ordnance Guided Missile School Trains NATO Personnel

By Norman L. Baker



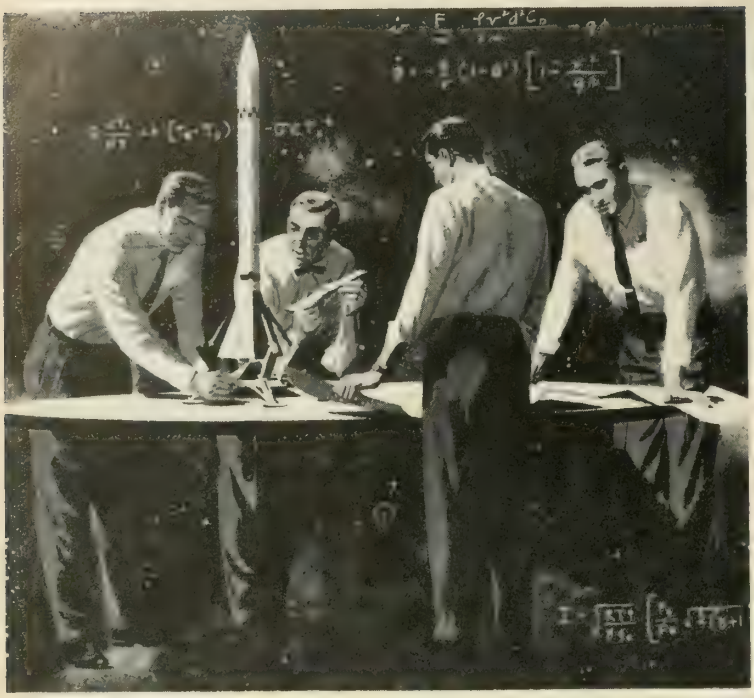
THE U.S. ARMY Ordnance Guided Missile School of Redstone Arsenal, the Army's only activity devoted exclusively to guided-missile training, has taken on the international look in recent months. Since the school was formed in 1952 students from this nation's armed forces and from five foreign nations have received training at the school.

Students from NATO nations are the latest addition to OGMS. First

LEFT—OGMS Corporal instructing group of Italian officers during class in NIKE-AJAX familiarization. BELOW—MISSILES AND ROCKETS editor Norman L. Baker interviews Maj. Ejvin Larsen, 1st Lt. Herman Dangaard and Lt. Bert Okholm, part of the initial contingent of personnel from Denmark to enroll at OGMS. The first Danes and Norwegians are receiving training to qualify them as interpreters for the main body of students.



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foreign students to be enrolled were from Great Britain and Canada. The first British class graduated in March 1956. This year students from Norway, Denmark and Italy have enrolled in the first step toward initiation of the NATO training program.

The first of the NATO personnel are comprised entirely of officers carefully selected from their country's armed forces. Representing only a handful of the NATO personnel that will eventually be trained at OGMS, the first groups will later be utilized as interpreters and instructors for the personnel that will follow.

NATO training is currently concentrated on the *Nike-Ajax* surface-to-air missile. This training is restricted to the supply, repair and maintenance aspects of the missile system. The operational phase of training is conducted at Fort Bliss, Texas. Later, the units trained at Bliss and OGMS will be merged into complete missile-systems units and will receive additional instruction before returning to their home countries.

With the exception of two officers, all personnel interviewed by m/r editors are being exposed to guided missiles for the first time.

Although none of the officers were volunteers, when ordered to leave their homes and attend the OGMS they expressed eagerness for the assignment. Most are married and are living with their families in homes around the Huntsville area. Morale is very high, apparently due to enthusiasm for their assignments and for the opportunity of visiting the U.S.

A per diem payroll allotment puts



1st Lt. Domenico Loda and 2nd Lt. Virgili Luigi of the Italian Air Force, students at OGMS, who were impressed by the NIKE-AJAX.



Officers of the Italian Air Force probe the "insides" of a NIKE-AJAX surface-to-air during a class in repair and maintenance.

the NATO officers salary on a comparable basis with that of the U.S. officer. This has avoided a compromise in their standard of living. A minor complaint of the officers was the lack of those foods that can be found in abundance only in their home countries. Several of the trainees have made previous trips to the U.S. and have had only minor difficulty acquainting themselves with our customs.

The NATO personnel are taking the same courses as the American students with the same completion date scheduled. The basic prerequisites for the NATO students are identical to U.S. Army personnel requirements, with the additional stipulation that they have a general knowledge of electronics and mathematics.

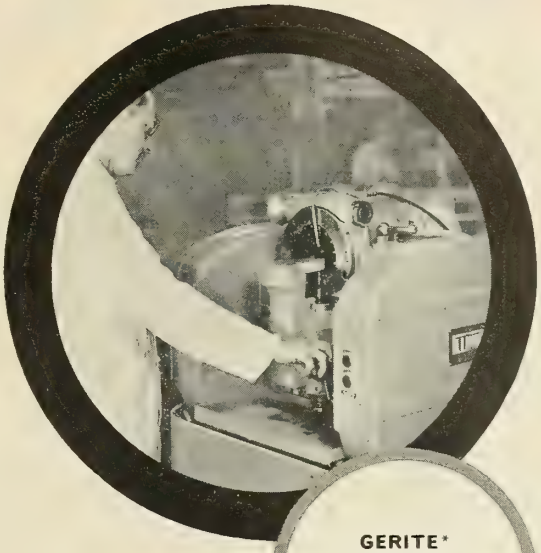
The Italians, latest group to enroll, are all Air Force personnel. In Italy the Air Force has complete jurisdiction over all guided missiles. Three major branches of the Italian Air Force are represented in this class—flying, service and engineering. All have technical backgrounds: some are thoroughly trained in electronics and others in radar. A notable feature of the officers' background is that all are in a career category and have expressed the desire to continue their profession in the guided-missile field.

The first groups of Norwegians and Danes are here primarily as interpreters. They are serving a dual purpose in being here. When finished with their present courses, they will remain as interpreters for the main body of students due to arrive in the next few months.

On returning home, these men will hold a unique and respectful position in their countries' armed services. The Netherlands may be the next NATO country to send personnel to OGMS for training. These men will be technicians from the Dutch Air Force selected for training in the *Nike-Ajax* system.

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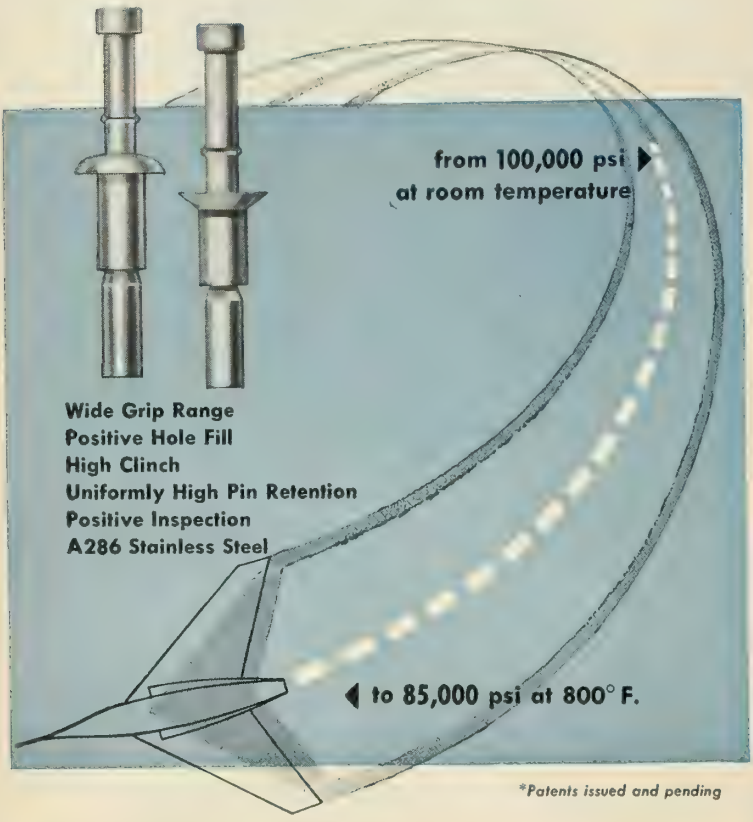
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at OGMS that the NATO training operation can be anything but a complete success. Minor language difficulties, which will be eliminated when the interpreter staff is trained, are compensated by the enthusiasm and dedication expressed by the NATO students.

One of the instructors stated, "The NATO students are constantly looking ahead, staying one step ahead of the instructor, anticipating the next move. The students utilize the full time allocated when taking exams. They weigh every possibility on each question and then constantly review their decisions."

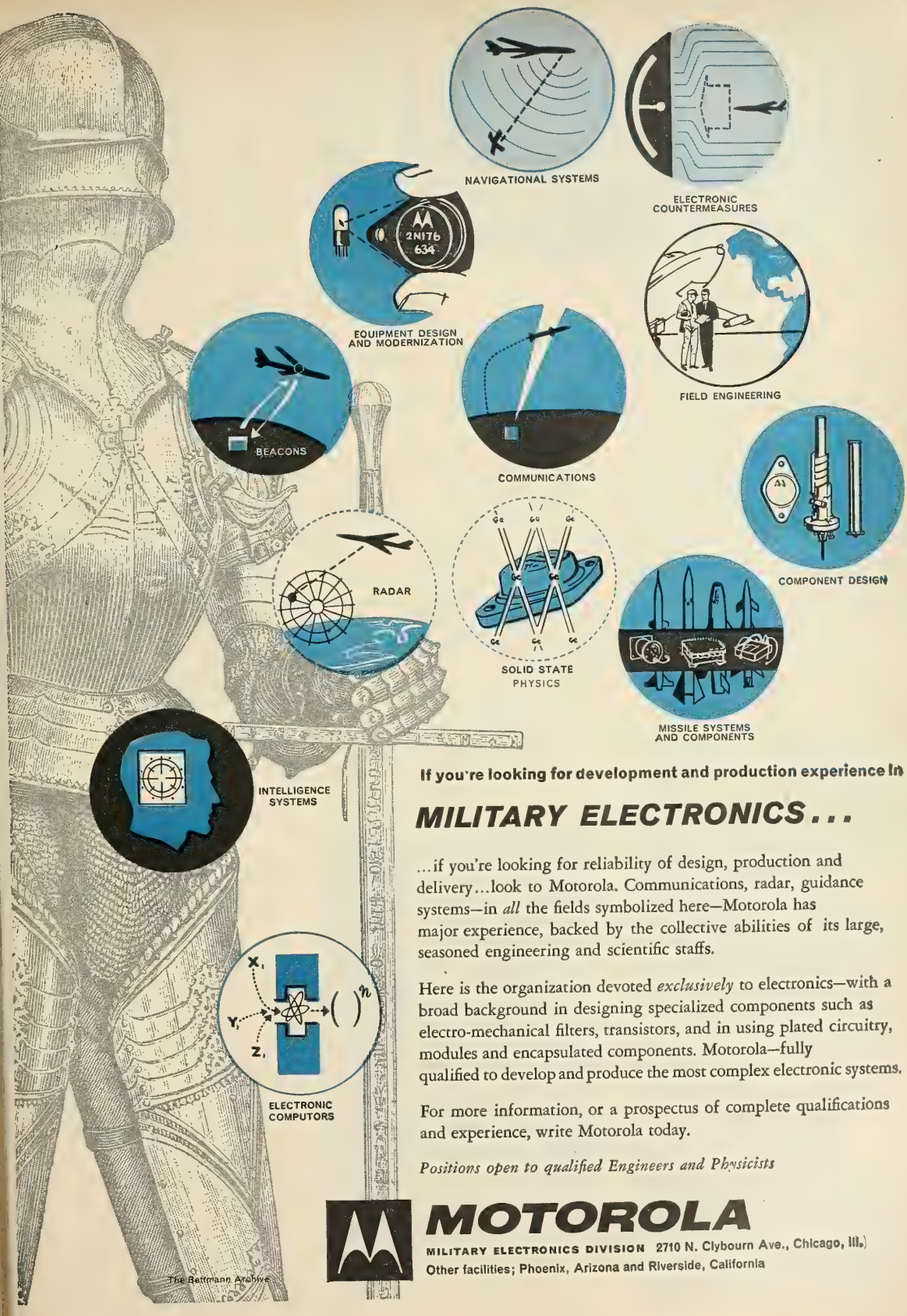
NATO training at OGMS currently comprises only a minor portion of the school's facilities and enrollment. OGMS has more than doubled in size in less than two years and is expected to double again in the next year. Total strength of the school stands just under 1750 persons compared to less than 800 in July 1955. Present number of students in training is in excess of 500 as opposed to 282 in July 1955 and 348 in July 1956. The remaining number make up the permanent party of staff, faculty, office, advisory personnel and the Unit Training Center staff. UTC is a division of OGMS devoted to training completely formed military units.

Personnel figures also include nine civilian contracting firms located on the base. OGMS employs approximately 100 field representatives from Philco, RCA, Firestone, Gilfillan, AASLI, Douglas, Western Electric, Chrysler, and North American.

OGMS now conducts 23 courses of instruction on the *Nike-Ajax, Corporal,* and *Redstone* missile system. Five units are currently undergoing training in the Unit Training Center. Plans are being formulated for adding the *Nike, Hercules, Dart,* and *Lacrosse* missile systems within the near future.

In preparing for the increased training load that will follow as a result of the addition of new missile systems, OGMS is in the midst of a $15-million building program. The construction program includes three class and laboratory buildings, two shop buildings, a technical library, a training aids shop, a special electronics-maintenance shop, and a special wheel vehicle maintenance shop.

Col. Henry S. Newhall, Commandant of OGMS, commenting on the present expansion program, stated, "These facilities will provide for new missile systems as they are developed by the Army. For, as new systems are added to the Army's arsenal of long range weapons, additional courses will be added to the school." ★



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The French Air Force CT 20 in the assembly area of the SNCA du Nord manufacturing plant. The CT 20 is one of the most advanced target missiles now in production in France.

French Missile Production

By Jean-Marie Riche

PARIS—Although the French authorities are very reluctant to discuss their progress in the missile field, the concentrated efforts of their aviation industry during the past ten years is beginning to pay off. Some of the hardware resulting from this work has now reached the production stage. And in one field—antitank weapons—the products are described as among the best existing in the world.

Some information has been released about the SS 10 and SS 11 antitank missiles. At the recent Salon de l'Aviation in LeBourget, the SS 10 was on display with two air-to-air weapons of SNCA du Nord and Matra which are now reaching the production stage. Some experimental vehicles were also shown, stressing French interest in other directions. The practical meaning of this research effort is not known.

French policy in the missile field was, however, outlined earlier this year by the present premier of France, then the defense minister, Bourges-Maunoury. The head of the French government was the first politician to warn the nation that it was entering the missile age. "The conclusion of the present research effort should be the production of an arsenal of defensive and retaliation weapon-systems without which French independence could not be guaranteed." The French are now at work on the development and construction of a surface-to-surface strategic missile (sol-sol strategique), with a range estimated between 1600 and 2000 nautical miles. This is a formidable challenge for industry. Production will require pooling of efforts by the major aviation and electronics manufacturers. This weapon, which may be armed with nuclear warheads, will help the current experimental work on surface-to-air and air-to-air missiles.

French manufacturers have asserted that missiles would be the ultimate result of experimental aircraft like the hybrid interceptor *Trident* of Sud-Aviation, *Leduc 022* and *Griffon* of Nord and like the *Flying Atar* VTO of SNECMA. The first *coleopter*, expected soon, and the *Trident* are equipped to fly by radio-control.

Although missile-minded, French industry is hampered by skimpy appropriations, only a small fraction of what it takes to produce a family of weapons like those in the U.S., the USSR or even Great Britain. More money is going for missile research, however. In 1955, of industry's total research grant, only 22.6 per cent went to missiles. In 1956, this was raised to 30 per cent and in 1957 to 31.6 per cent.

In view of the increased emphasis on missiles, the coming months will see the formation of groups with which aircraft research activities and electronics companies will associate themselves. In some cases, the aircraft companies will absorb research departments of electronics companies. These developments should give a boost to an effort which may have been somewhat delayed through the reluctance of the majority of the industry to







SS 10 (above left) and SS 11 (left) are surface-to-surface antitank, antiemplacement missiles powered by a solid rocket motor. Missiles are controlled by transmitting signals through two wires which unwind from a drum. The MATRA 510 (above) is an air-to-air missile powered by a two-stage solid rocket motor. Missile carrier is the TRIDENT.

abandon "classic" production items in favor of missiles.

In addition to aviation companies, work has been undertaken in the missiles field by DEFA and the Army Arsenal, which was responsible for the development of the surface-to-air *Parca* missile, whose production status is not clear. ONERA, the French counterpart for NACA, has also produced interesting test vehicles, some of which were on display at the Bourget exhibition.

Testing of French missiles takes place at the Colomb-Bechar range in South Algeria, a well-equipped interarm testing base at the fringe of the Sahara desert.

The SS 10 and SS 11 are surface-to-surface antitank and anti-emplacement weapons designed by SFECMAS, a company now operated by the Societe Nationale de Constructions Aeronautiques du Nord. Equipped with one solid rocket motor for acceleration and one for cruising, they are guided by two isolated electric wires which unwind from a drum. A small gyroscope, especially developed for the missile, is described as its best construction asset. Their warhead is provided with a hollow charge which can pierce armor plates 400-500 mm thick.

In production for about four years, the SS 10 is used as standard antitank equipment by several armies including the French and German. Recently demonstrated to experts of NATO, it has been recommended for general adoption by the NATO forces. The SS 10, whose operation is very simple (guidance by straight visual reference), can be used either as a surface-to-surface antitank or anti-emplacement weapon or, mounted on helicopters or light planes, as an air-to-surface weapon.

The SS 11, derived from the SS 10, is a smaller diameter missile, also guided by wire, but whose range is more than twice that of the SS 10. The velocity of the missile at the end of its cruise is twice that of SS 10. The warhead of the SS 11 is also heavier.

Nord 5103

This missile has been designed by SNCA du Nord for the armament of transsonic, subsonic or supersonic interceptors. It is characterized by its pointed warhead and its four cruciform wings which are sharply swept.

MATRA Type 510

MATRA (Societe Generale de Mecanique-Aviation-Traction), a company closely connected with the Breguet Aircraft Co. has developed several air-to-air missiles from which the M510, now in production, was developed. The initial M04 test model was followed by the M20 model (range: 1 mile; Mach 1.5) which is produced for interceptors in the *Mystere IV* class.

MATRA developed the M051 missile for the *Vautour*. Equipped with beam guidance or homing head, this missile has a length of about 9'10", a weight of 350 lbs. and can reach a very high speed. Propulsion unit is a two-stage solid-propellant rocket motor. The MATRA 510, also of canard design, has a burnout velocity above Mach 2 and an optical homing head. It is part of the *Trident II* weapons system.

SE 4200

This surface-to-surface missile is still on the secret list. The warhead is mounted in a pod under the fuselage. Missile is launched by two boosters from platform.

Specific Data:

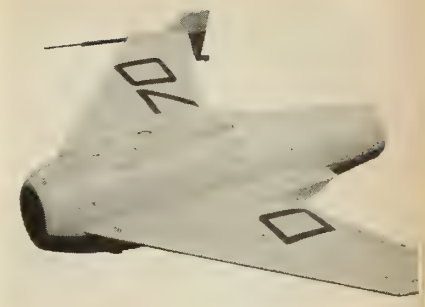
Manufacturer:	Sud-Aviation
Mission:	surface-to-surface
Range:	55-60 n. miles
Length:	10'
Span:	7' 1"
Launching Weight:	1400 lbs.
Velocity:	subsonic (Mach 0.9)
Guidance:	radio
Powerplant:	ramjet cruise plus two solid-propellant boosters (take-off)
Status:	in production

Target Missiles

CT 10—Manufactured by SNCA du Nord for about 10 years. Used by the French Air Force, the UK Royal Navy and the services of several other countries. Length: 35'. Velocity: 280 mph.

CT 20—A development of the CT 10, manufactured by SNCA du Nord. Has flight time of one hour. Velocity: Mach VO.9.

SE1502-1523-1524 — air - to - surface target missiles built by Sud-Aviation. ★









The majority of French missiles in production are of the aerodynamic cruise design with rocket boost and jet sustaining engines. Top to bottom—SE 4200, a subsonic ramjet surface-to-surface missile with a range of 60 miles. CT 10, a target missile that has been in production for about 10 years. Velocity 280 mph. CT 20 is a development of the CT 10. The CT 20 is also subsonic with a flight time of one hour. Both missiles are jet propelled with solid propellant rocket boost. CT 10 is similar in configuration to the early V-1. SE 1524 is an air-to-surface missile in limited production by Sud-Aviation.

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1957

Propulsion Engineering

By Alfred J. Zaehringer



AMMONIA IS SAFE say German researchers. Explosive limits of NH_3-air mixtures are 16-27% while H_2-air is 9-66.3%. The ammonia explosion limits decrease with humidity and are of less force than hydrogen. Few ammonia combustive explosions have been encountered.

FREEZING POINT OF TETRANITROMETHANE can be depressed to −20 by use of an N_2O_4 additive. The nitrogen tetroxide, says an Italian patent, also makes for easier reaction with amines or liquid ammonia when TNA is used as a liquid-rocket propellant.

OXYGEN PLANT SAFETY has been outlined by Linde Co. in Munich. Two big factors in preventing explosions in separating plants are control of initiating conditions and elimination of explosive materials. Former method eliminates mechanical effects, sparks, isolated drying in crevices and removes reactive materials (radicals, ozone, etc.). Latter consists of eliminating hydrocarbons, COS, and H_2S. Acetylene is said to be the most dangerous troublemaker.

MORE AMMONIUM PERCHLORATE for solid propellants is in sight. One Norwegian electrochemical firm is trying to sell the high energy oxidant on the East Coast to Atlantic Research and Thiokol. U.S. capacity for AP, though, is still ample. The Norwegian AP could lead to lower prices thus stimulating use. Continuous nitration process for production of nitroglycerine and other propellant materials has been introduced in Sweden. Nitroglycerine Aktiebolaget (founded by Alfred Nobel in 1884) at Gytorp uses nitration by injection whereby products in nitration stages are removed as a nonexplosive emulsion. Thus, only a small amount of free NG is actually present in the process. The firm can eliminate conventional mounding and need only use a concrete wall to separate the nitrator and the control area. NG is a vital ingredient in modern double-base solid propellants.

BORON FUELS IN BRITAIN: American Potash & Chemical has a subsidiary now going in the UK which may introduce exotic boron fuels and high energy lithium oxidants.

EXOTIC OXIDANTS ARE IN THE WORKS. In addition to studying liquid ozone, Soviets at Moscow State University have bombarded LOZ with atomic hydrogen at −196° C. A deep blue film, which solidifies, results. The solid, colored blue by the LOZ, decomposes violently with oxygen evolution and leaves behind a 30% water solution of hydrogen peroxide. The experiments, which are also underway at other facilities, are aimed at the synthesis of hydrogen superperoxide (H_2O_4). Another project is concerned with the deep thermal decomposition of methane.

AUTOMATIC CONTROLS FOR ROCKETS are being investigated by the Center de Recherches Hydrauliques et Electriques, Paris. Hydraulic servos are controlled by electrical inputs. Particular attention is devoted to synthetic fluids for high-temperature operation. Several models, ranging from 5-20 horsepower, have been built.

NUCLEAR PROPULSION FOR ROCKETS is being studied by the Swiss Oerlikon firm. A design study project has been reported underway.

WORKING FLUIDS FOR ROCKETS were studied intensively by Bremen engineers. At temperatures of 2500-3250°C and pressures of 16-64 atm, gamma is remarkably alike for the gases, hydrogen, water, nitrogen, air, oxygen, hydrogen chloride, and carbon dioxide. At a given temperature, the average molecular weight increases with pressure. With water as a working fluid (at 64 atm & 3250°C), a theoretical velocity of slightly over 12,000 ft/sec is obtained.

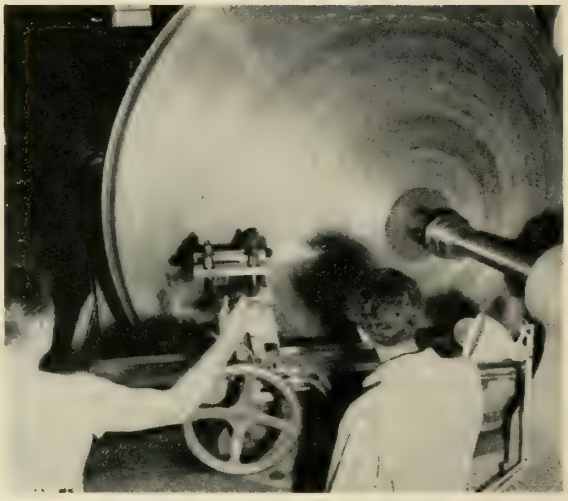
EVER HEAR OF A "FIREFLY HUNT"? We just heard that observers who will take part in visual tracking of the *Vanguard*-launched satellite may conduct such hunts. According to a bulletin put out for Moonwatchers, as they are called, the firefly often seriously detracts an observer looking through a tracking telescope. The bulletin said, "At least one Moonwatch group conducts a firefly hunt around the station before the observing session." The firefly's quick flash *could* be mistaken for a passing satellite.

METAL SPINNING

New Imported Equipment Spins Economy into Aircraft and Missile Parts

Welding operations are eliminated, weight is saved, unit cost reduced with new, imported machinery used to spin heavy or thick-walled aircraft and missile parts. Below, missile cylinder was spun "hot" on the lathe. Prior to metal spinning, manufacturers had been wrapping and welding the body, then welding on bottom. This cylinder was made from flat, round blank of ½" aluminum, 60" in diameter. Finished wall thickness is .380" with a 125 finish. Machines are from Germany.

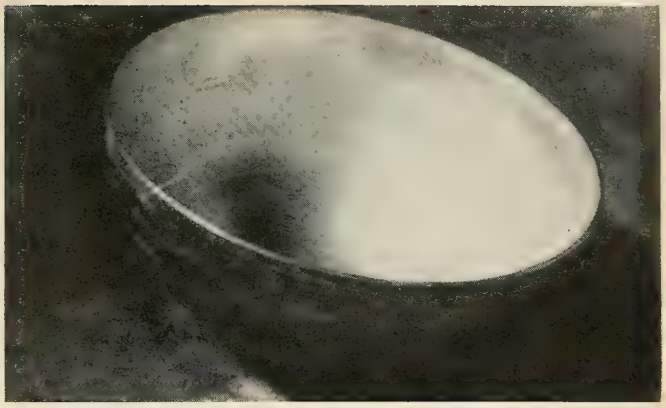




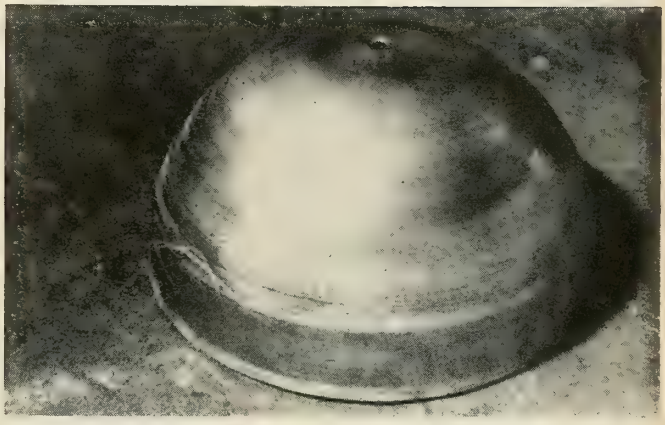
Cold spinning ⅝" aluminum alloy to an 8' finished part for ICBM pressure bulkhead. Used here is Model Plb 1200 hydraulic spinning and planishing lathe. German manufacturers are Leifeld & Co.



Right, cone of ⅝" magnesium, hot spun in two parts on LEICO Model Plb 1200. Previous to new method, welded heavy or thick-walled parts caused warpage which in turn required an inside and out operation. The machines are now being used in many parts of U.S.A.

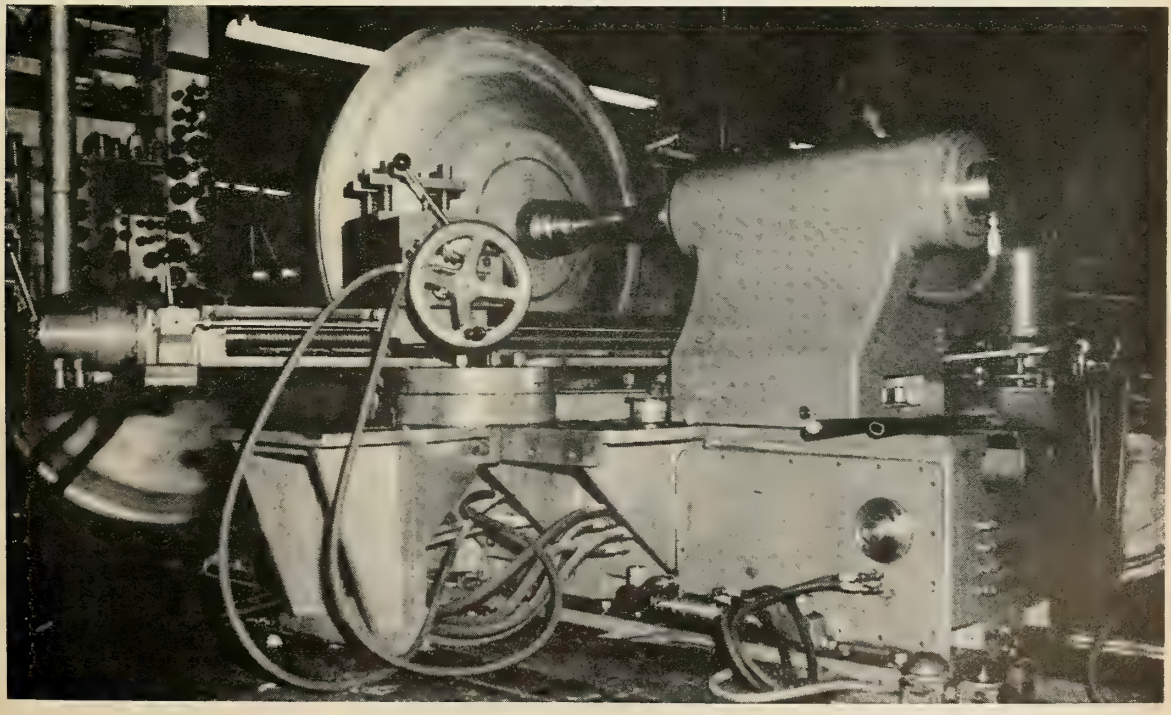


Titanium hemisphere 3/8" thick, hot spun on LEICO Model Plb 600 lathe. New process makes it possible to finish one symmetrical piece to the point where it is ready to use as it leaves the lathe. First complete metal spinning set up in this country was Hydro Metal Spinning Corporation's installation of five lathes and one hydraulic flow turning machine in Los Angeles, Calif.



Stainless steel 1/4" type 304 hot spun on LEICO Model Plb 600. Spinning diameters possible run from 52" to 130 1/4", available through various sizes of the fully hydraulic machines. They can produce 5/8" aluminum and magnesium, 3/8" titanium and 7/8" cold rolled stainless steel sheets.

Picture below shows a high efficiency metal spinning and planishing lathe, Model Plb 1200. This machine will cut the fabrication cost of aircraft and missile parts. The company's representative in the United States is Albert H. Wilhelm, 1020 W. 20th St., Los Angeles, Calif.



COLD FORMING in missile production

COLD FORMING processes originally developed by Norris-Thermador Corp. for the fabrication of cartridge cases are now beginning to be used to produce cheaper and better metal components for rockets and missiles.

One good example is the new-type body being made for Aerojet-General Corp.'s long-established JATO unit. Formerly welded together from four separate parts, the chamber for the 15KS-1000 is now being drawn in one single piece in the large capacity presses at Norris-Thermador's Vernon, Calif., plant.

This method of forming makes possible lighter weight and a substantial cost saving for Aerojet. With no welds, the chamber has improved reliability.

Norris-Thermador manufactures a wide variety of products ranging from bath tubs to electronics equipment. It makes all the automobile wheels for all cars assembled on the West coast. Its first ordnance contract—1000-pound practice bombs for the Navy—turned out to be an unprofitable venture, but provided the company with much valuable experience. On its second Navy contract—for $1-million worth of aluminum cartridge containers—Norris-Thermador, then known as Norris Stamping and Manufacturing Co., developed the ingenious methods and machinery to produce deep drawn seamless containers, an achievement considered impossible at that time.

Evidence of the company's resourcefulness was demonstrated again when it solved one of the biggest production problems of World War II by developing low cost methods of producing satisfactory antiaircraft cartridge cases from steel instead of brass.

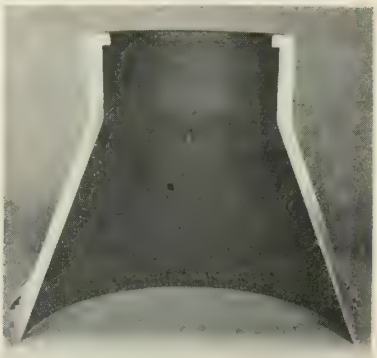
Not long ago, Norris-Thermador turned out its 55th million artillery-size cartridge case. But at the end of Korea, it found itself with 13 lines of shell cases and dwindling orders in this particular phase of its operations. That's when its government products department focused its sights on the rocket field. Subsequent production includes more than 2 million rocket motor tubes for the widely used 2.75-inch *Mighty Mouse*, produced by the cold drawn process.

Norris-Thermador makes both the JATO chamber and the aft cap for Aerojet's Navy JATO unit, each in one-piece operations. The chamber is cold formed with an integral spud section from an AISI 4130 steel blank. The aft cap is cold formed from a mild steel blank. Using this process, Norris-Thermador guarantees a minimum yield strength of 100,000 psi for the chamber side walls. Day-to-day values actually are 120,000 psi.

This company also has a subcontract from Phillips Petroleum Co. to produce main body and nozzle for the M15-A1 JATO for the Air Force, and a plant for this purpose was built last year in Waco, Tex. For this JATO unit, Norris-Thermador also manufactures the fixtures with which it is fastened to the aircraft. The Phillips-designed JATO, however, incorporates different design and therefore different manufacturing processes than the Aerojet.

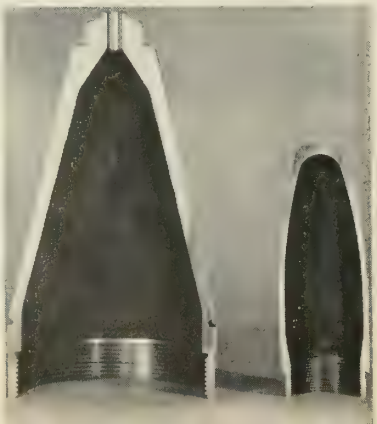
Norris-Thermador's ability to draw





The rocket business is basically a low-cost business. As such, it enjoys the privilege of a greater variety of production processes. These pictures show the great number of different shapes that can be made by cold forming and cold extrusions. These are examples of Norris-Thermador's production.





and extrude items with varying wall thicknesses is attracting increased attention from rocket and missile designers. Its cold forming operations extend into the 4130 and 4140 alloy steels as well as in mild steels, aluminum, copper and brass.

"We are just on the threshold of what can be done with metals," said Larry Shiller, chief research and development engineer.

One of Norris-Thermador's newer cold forming projects is for the body of the *Hawk* for Raytheon Manufacturing Co., which has the prime contract on this Army missile. To be built in two pieces of 4130 steel 95 inches long and 14 inches in diameter, with a girth weld, this is reported to be the longest cylindrical item ever formed by deep drawing.

So far, Norris-Thermador's applications have been to small and medium-size rockets or missiles. "But we are alert to the larger sizes," said Donald P. White, vice president of the company's government products division.

Norris-Thermador's Vernon plant is one of the largest and most comprehensive metal forming facilities in the West, with a press department housing mechanical presses ranging from 25 to 400 tons and heavy hydraulic presses ranging from 45 to 6000 tons capacity. Military work constitutes only a small part of Vernon production, but two other plants are devoted entirely to government products. These are the Riverbank Ordnance plant, a joint Army-Navy facility near Modesto, Calif., where Norris-Thermador operates at a very low rate—just enough to maintain an organization which can be rapidly expanded if an emergency should arise—and the JATO plant at Waco, Tex. ★







Parts that can be made by cold processing include nozzles, bulkheads, feed fitments, nose cones, casings, entire motors (in the case of small ones), etc. Directly to left are motor bodies extruded and deep drawn from an AISI 1030 steel slug. Below are cold-worked nozzle plates from AISI heat treated steel.

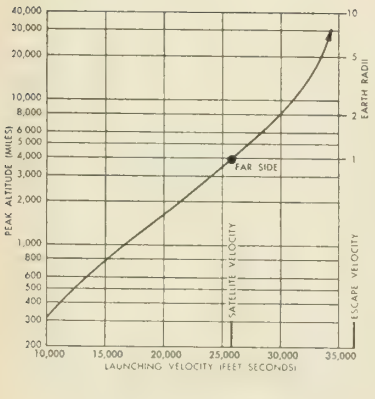


Project Far Side

Man's first stride into space uses off-the-shelf hardware

By Prof. S. F. Singer

Physics Department
University of Maryland



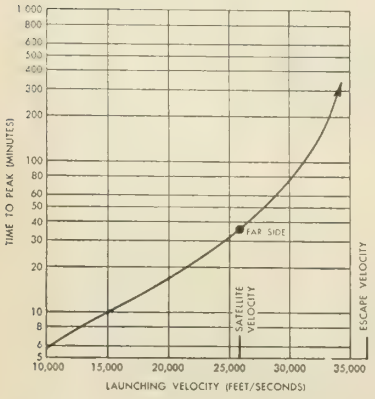


Figure 1. Parameters of FAR SIDE concept.

A NEW DIMENSION has been added to high altitude research: *Far Side,* which will explore space out to one earth radius (4000 miles) and possibly higher. Conceived by scientists of the Air Force Office of Scientific Research and developed by Aeronutronic Systems, Inc., the *Far Side* vehicle is a low-cost solution for reaching the highest altitudes yet attained by man. It is a multistage rocket launched at high altitude to overcome the atmospheric drag; specifically it is a four-stage combination of ten solid rocket motors lifted by a Skyhook balloon to an altitude of over 100,000 feet (m/r August 1957, p. 45).

The 1900-pound vehicle carries only a three-and-a-half-pound payload, but thanks to instrument miniaturization this tiny package buys a lot of scientific research.

High Altitude Vehicles

Because of its extreme altitude capability *Far Side* operates in a class quite different from that of other research rockets such as the *Aerobee, V-2, Viking,* or *Dan* (m/r March 1957). It is designed specifically to explore the exosphere region above the ionosphere, sometimes called the outer ionosphere. This is the region above 250 miles where collisions between atoms become so rare that we can truly speak of it as the boundary of space. While other research rockets investigate the properties of the lower atmosphere and ionosphere, the *Far Side* vehicle studies the nature of the space around the earth, eventually as far as the moon and beyond.

It opens up the possibility of discovering radically new scientific phenomena present in interplanetary space. In a sense these investigations supplement the research to be carried out in the first earth satellites: whereas the earth satellite explores for long periods of time at about 300 miles altitude relatively close to the earth, the *Far Side* vehicle thrusts vertically out into space over ten times as high. It can reach regions which are not accessible to the satellite, but it does not have the long satellite lifetime.

Team Behind Far Side

Project *Far Side* represents the fruitful collaboration of two highly qualified organizations. The Air Force Office of Scientific Research has been working on space problems for some time by supporting research on cosmic rays, plasma physics and interplanetary exploration by means of radio "whistlers."*

This support of basic science according to AFOSR commander Brig. Gen. H. F. Gregory is in accord with the mission of AFOSR "to undertake

** low frequency radio waves produced by lightning discharges and guided along magnetic force lines to the opposite hemisphere (Fig. 8.)*



Fig. 2. Propulsion Study for Escape Vehicle

In this study the same criteria are used as in the *Far Side* design:

1) A four-stage rocket launched from a balloon to obtain maximum effectiveness. (Compare this with a two-stage approach by Kurt Stehling in m/r October 1956.)

2) Solid-propellant motors are used because of greater simplicity and lower cost in the size range considered here.

3) The stages are designed with optimum matching to give the best overall performance in terms of highest velocity with minimum all-up weight.

The following assumptions are made with regard to the propulsion system:

1) The maximum velocity obtainable depends on the maximum weight balloon can carry and the minimum useful weight for the payload. We assume here a 3000-pound maximum balloon load and a payload weight of two-and-a-half pounds.

2) Solid propulsion units are used in this design which have a vacuum specific impulse of 250 seconds and a mass ratio of 0.86.

	STAGE			
	#1	#2	#3	#4
Initial Wt.	2500	416	69.5	11.5
Final Wt.	350	58	9.7	1.6
Propellant Wt.	2150	358	59.8	9.9
Total Wt.*	3000	500	83.5	14.0
Effec. Mass Ratio		0.72		
Velocity increase per stage		10,200 ft./sec.		

*Incl. weight of following stages and payload.

The final velocity is 40,800 feet per second. This exceeds the escape velocity from the earth, which is 36,000 feet per second near sea level.

This vehicle could therefore escape entirely or attain extremely high altitudes if deflected and returned to the earth by interaction with the moon's gravitational field (Fig. 2).

exploratory and pioneering research to maintain the USAF's dominant technical position," (m/r July 1957, p. 105).

The AFOSR attitude toward space research has also been forcefully stated by Col. William O. Davis, deputy commander, operations, (m/r June 1957), who pointed out that "the space around the earth is becoming our next military environment; there is an intrinsic necessity that we understand this new environment."

Dr. Morton Alperin, who heads the Directorate of Advanced Studies of OSR in Pasadena, Calif., has been laying the groundwork for space research by supporting research on advanced solid propellants of high specific impulse and research on unique and exotic propulsion systems based on magnetohydrodynamic principles.

It was under his guidance that Project *Far Side* was first outlined and put together. The industrial prime contractor, Aeronutronic Systems, Inc., seemed a natural to carry out the development and build and launch the vehicle. Vice president Ernst H. Krause initiated the upper-atmosphere rocket-research program at NRL at the end of World War II.

Its other key scientists are also well known in the upper-atmosphere and cosmic-ray field—men like Montgomery H. Johnson, Ralph J. Havens and Ernest Martinelli. Project manager is Herbert L. Karsch, formerly the technical director of the White Sands Proving Ground, where he was responsible for the early V-2 program and

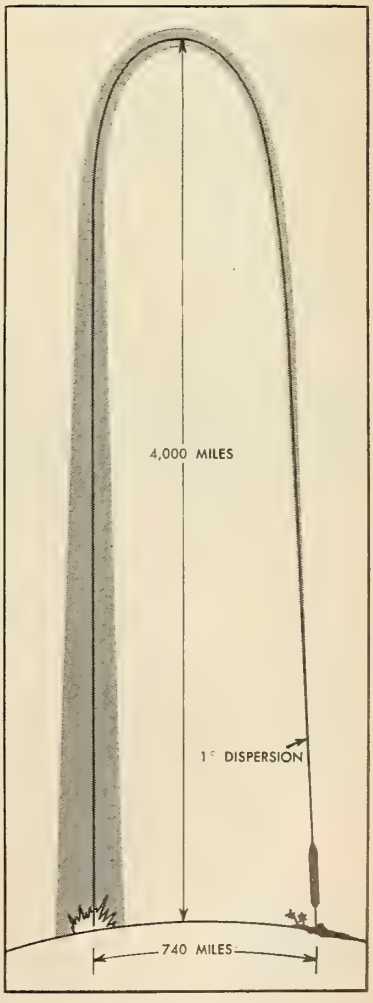


Figure 3. Trajectory of 4000-mile FAR SIDE rocket.

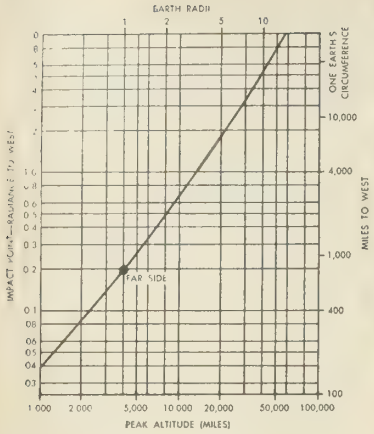


Fig. 4. Relationship of a altitude to impact point.

other rocket programs. In charge of the electronics portion of the *Far Side* program is Harrison Smith, Jr., formerly head of the NRL telemetering program.

Technical Aspects

Together with General Mills' technical staff, these men worked out a unique launching scheme for the 23-foot long, four-stage rocket vehicle. For the critical release phase on the ground they designed a mobile launch truck. Other knotty problems had to be solved: stability during firing, stage separation with minimum dispersion, and intense aerodynamic heating with a maximum velocity of nearly 18,000 miles per hour.



RESEARCH GOALS

Fig. 5. Nature of Outer Ionosphere (controlled mainly by earth's gravitational field and solar radiation).

What is the concentration of atoms at different altitude levels? What is the composition? Where does hydrogen take over? What fraction of atoms is ionized? What are the electrical properties? How rapidly does the temperature rise? How fast does the atmosphere evaporate into space? How far up does the gas rotate with the earth? What "winds" exist?

Propulsion

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Coil voltage:	6.3V sine, square, pulse wave
Coil resistance:	85 ohms
***Phase lag:**	55° ± 10°
***Dissymmetry:**	Less than 4%
***Switching time:**	15° ± 5°
Temperature:	—55°C to 100°C
Operating position:	Any
Mounting:	Flange or plug-in—fits 7-pin miniature socket

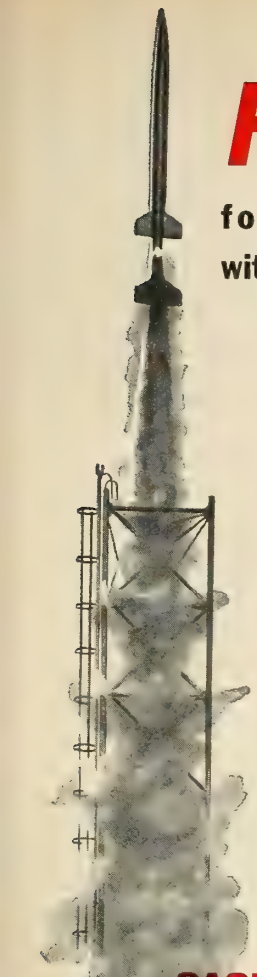
*These characteristics based on sine-wave excitation.

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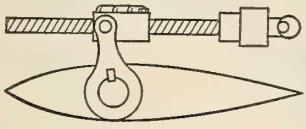
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FAIL-SAFE ACTUATION

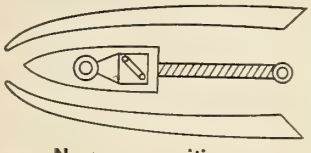
for guidance and control in difficult environments with SAGINAW b/b SCREWS and b/b SPLINES



TYPICAL APPLICATIONS

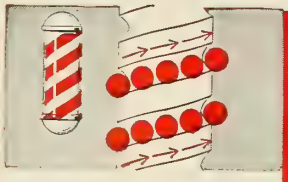


Control surface actuators

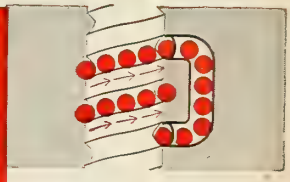


Nose cone positioners

Evelon positioners • Afterburner controls • Speed brake actuators • Rocket engine displacement actuators • Clamping mechanisms for missile boosters • Fuel controls (3-dimensional cams) • Black box tuning devices—telemetering and guidance systems • Antenna coupler tuning mechanisms



Nut *glides* on steel balls. Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.



At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

1 VITAL POWER SAVINGS. With guaranteed efficiency of 90%, Saginaw b/b Screws are up to 5 times as efficient as Acme screws, require only ⅕ as much torque. This permits much smaller motors with far less drain on the electrical system. Circuitry is greatly simplified.

2 SPACE/WEIGHT REDUCTION. Saginaw b/b Screws permit use of smaller motors and gear boxes; eliminate pumps, accumulators and piping required by hydraulics. In addition, Saginaw b/b Screws themselves are smaller and lighter. Units have been engineered from 1½ in. to 39½ ft. in length.

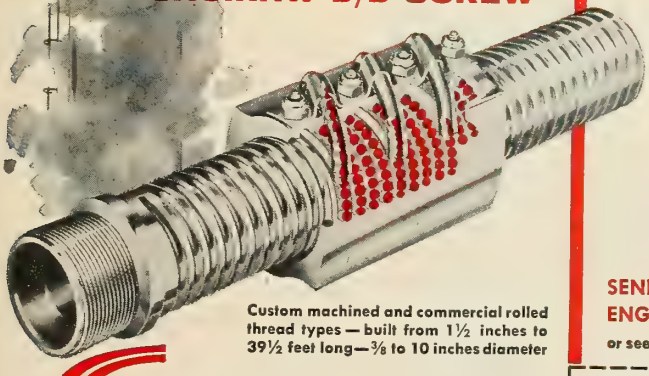
3 PRECISE POSITIONING. Machine-ground Saginaw b/b Screws offer a great advantage over hydraulics or pneumatics because a component can be positioned at a predetermined point with precision. Tolerances on position are held within .0006 in./ft. of travel.

4 TEMPERATURE TOLERANCE. Normal operating range is from −75° to +275° F., but assemblies have been designed in selected materials which function efficiently as high as +900° F. These units are practical where hydraulic fluids have lost efficiency or reached their flash point.

5 LUBRICATION LATITUDE. Even if lubrication fails or cannot originally be provided because of extreme temperatures or other problems, Saginaw b/b Screws will still operate with remarkable efficiency. Saginaw units have been designed, built and qualified for operation without any lubrication.

6 FAIL-SAFE PERFORMANCE. Far less vulnerable than hydraulics. In addition, Saginaw offers three significant advantages over other makes: (1) Gothic arch grooves eliminate dirt sensitivity, increase ball life; (2) yoke deflectors and (3) multiple circuits provide added assurance against operating failure.

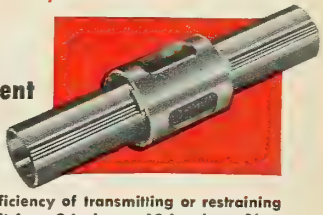
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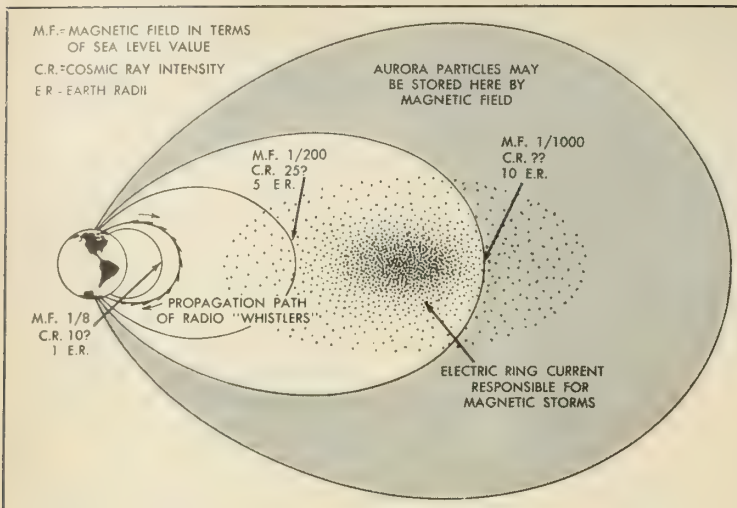


Fig. 6. Radiations in the Outer Ionosphere (controlled mainly by earth's magnetic field)

How rapidly does the magnetic field fall off? Does the ring current exist? How does the cosmic ray intensity increase. What is its value in free space? Where are the auroral particles stored? How are they accelerated before bombarding the ionosphere? Does the space intensity of meteoric dust increase with altitude?

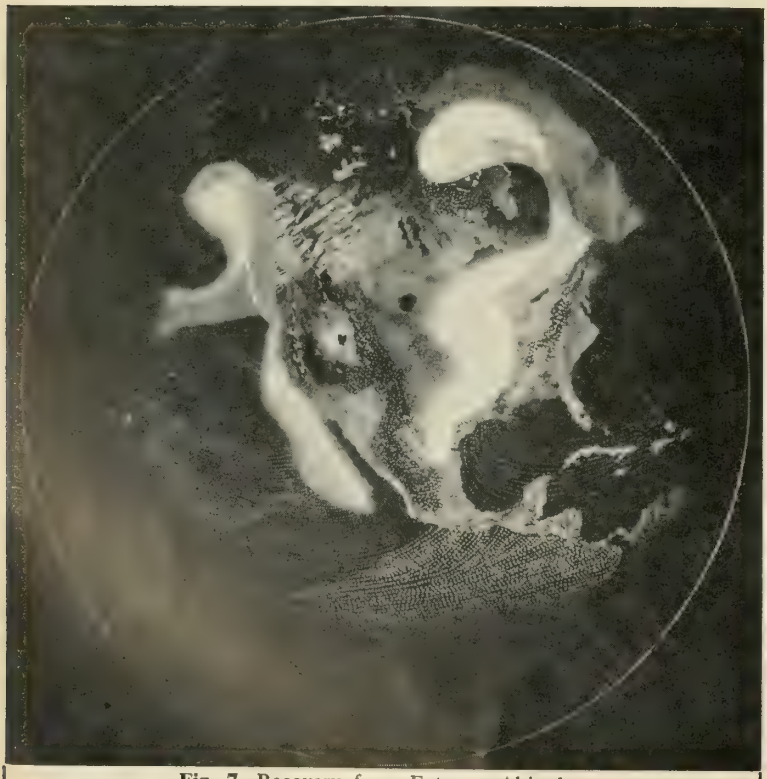


Fig. 7. Recovery from Extreme Altitudes.

Photographic film; high-altitude pictures for weather studies. Cosmic ray emulsions; heavy primary particles; biological specimens (bees, fruit-flies); prolonged exposure to outer space radiation—all will aid science.

because of the excellence of its solid propellant motors. Thiokol's *Recruit* motor is a new achievement in efficiency, mass ratio and specific impulse, while Grand Central's *Arrow* motor duplicates the performance of its bigger brother but on a smaller scale.

The staging design follows a simple optimization principle. One can, to a first approximation, neglect atmospheric drag since the launching takes place above 98 per cent of the atmosphere.* The carrying capability of the launch balloon sets an upper limit to the vehicle weight. With an assumed four-pound payload, optimum performance of a four-stage design demands that each stage represent an increase of impulse by about a factor four. Thus, we achieve the *Far Side* vehicle design.

Since the mass ratio and the specific impulse for each stage are about the same, the velocity increments produced by each stage are about equal. In order to reach a final velocity of five miles per second (which incidentally is also the satellite velocity), a velocity increment of one-and-a-quarter miles per second is required for each stage.

If one deviates from this optimization principle, for instance, by making the velocity increments unequal, the whole combination loses in efficiency and the all-up weight must be greater.

As currently designed, the *Far Side* vehicle represents the most efficient combination of existing high performance rocket motors. By the same token, the *Far Side* vehicle also constitutes the cheapest solution for reaching extreme altitudes. As the performance of solid motors improves, higher velocities, and therefore much higher altitudes, become possible. The *Far Side* design philosophy is illustrated in the table of Fig. 1, which shows that an escape vehicle or moon rocket is easily achieved with motors having a (vacuum) specific impulse of only 250 seconds and a mass ratio of 0.86.

Dynamics and Trajectories

With vehicles reaching such extreme altitudes, the radius of the earth itself (4000 miles) becomes the unit of measurement. Even the word "altitude" loses significance and is replaced by "distance from the earth."

Increasing the altitude beyond one earth radius is not very difficult: only a small increase in velocity is necessary. This can be seen in Fig. 1, or

** Because it will be launched at high altitude, rocket motors can be designed for operation in near vacuum, which increases their specific thrust by approximately 15 per cent.*

by considering that at the peak the initial kinetic energy of the vehicle $\frac{1}{2}MV^2_{init}$ must all be given up to the potential energy of the gravitational field; i.e. at the peak of trajectory the body has zero velocity and therefore no kinetic energy, but it has a large potential energy because it has been lifted so high up against gravity.

By setting the two energy expressions equal, one can derive the peak altitude very simply in terms of an initial velocity.* It is interesting to note that with an initial velocity equal to the satellite velocity, about 5 miles per second, the vehicle will go up exactly one earth radius. If one were to direct the *Far Side* vehicle horizontally, it would become an artificial earth satellite.

It is seen also from Fig. 1 that an increase in velocity of only 40 per cent, up to seven miles per second will give the vehicle enough kinetic energy to overcome the earth's gravitational field altogether. It now escapes from the earth and never comes back, unless it encounters the moon and becomes redirected as indicated schematically in Fig. 2.

By arranging this "collision" with the moon's gravitational field in a suitable way, one can make the vehicle travel around the far side of the moon and return it near the earth, where it can relay what it has seen by means of radiotelemetry.

To those used to measuring rocket flight times in terms of minutes, the length of time the *Far Side* vehicle spends above the atmosphere may come as a surprise. The initial series of vehicles, which goes to 4000 miles, takes 1960 seconds to reach peak altitude, and therefore spends over an hour above the earth's appreciable atmosphere. Fig. 1 shows the relation between the initial velocity and time to peak ascent.

The high altitudes and long periods of flight affect the location of the vehicle's impact point. Normally a high-altitude rocket lands pretty close to its launching point. We are not concerned with effects of the earth's rotation since the dispersion due to inaccuracies in the thrust and aerodynamic influences is ordinarily much larger. For extremely high altitudes, however, the rotation of the earth becomes of major importance.

If the vehicle is launched at the equator, in addition to its initial velocity derived from the rockets, it also carries a tangential velocity of 0.3 miles per second due to the earth's rotation.

Seen by a distant observer, the vehicle describes a portion of an ellipse, a ballistic trajectory which intersects the earth. It takes the vehicle considerable time to describe its trajectory; in the meantime the earth, and therefore the launching point, will have rotated. Knowing the flight time, we can calculate how far the launcher has turned and determine the impact relative to the launcher.

The results of such a calculation are shown in Fig. 3: a vehicle which has been launched at the equator with an upward velocity of five miles per second, equivalent to the velocity of the *Far Side* vehicle, will impact 740 miles west of the launch point. We also show the impact dispersion in the presence of an assumed one-degree dispersion in the launching angle.

For much higher altitude vehicles the flight time runs many hours. We can, therefore, have the vehicle impact to the east of the launcher. For example, for an altitude of 10 earth radii the vehicle would impact close to the launcher (Fig. 4).

This large dispersion of the impact point is only one of the problems peculiar to these extreme-altitude vehicles. This particular problem can be overcome by launching the vehicle near the pole where the effects of the earth's rotation are negligible.

But the problem of radio communication still remains. The signal power decreases as the inverse square of the distance, so that at an altitude of 4000 miles the power received is only one per cent of that from 400 miles.

Since it is generally not feasible nor economical to increase the transmitter power beyond a certain limit, this drawback can be overcome in one of two ways: the sensitive area of the receiving antenna can be considerably increased to collect more power from the transmitter, or the amount of information transmitted can be reduced and, therefore, the bandwidth of the transmitter as well as that of the receiver. This cuts down noise in receiving circuits.

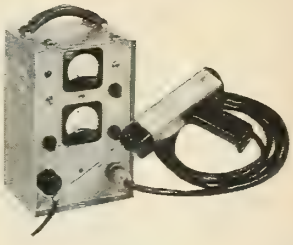
Scientific Applications

Because of its unique high altitude capabilities, *Far Side* explores for the first time the virtually unknown regions surrounding the earth, sometimes called the outer ionsphere, which reach from the exosphere, 250 miles up, out to about 40,000 miles. We generally consider the region beyond this limit as interplanetary space. But within about 10 earth radii, both the earth's gravitational field and the earth's magnetic

---

* $\frac{1}{2}V^2_{init} = g_o \frac{hR_e}{h + R_e}$ *where* g_o *is the acceleration of gravity at sea level,* h *the peak altitude above sea level,* R_e *the radius of the earth*

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field are strong enough to control what goes on.

The Outer Ionosphere

We know now from measurements with radio whistlers and from measurements of the zodiacal light that this region of the earth is not a vacuum but contains 600-1000 electrons per cc, and the same number of positive ions, mostly protons. In addition, we may have a large admixture of neutral atoms, but until now we have had no means of measuring their concentration.

The measurement of atmospheric density above satellite altitudes is probably the most important contribution of the *Far Side* vehicle. We suspect that there is an inner region in this outer ionosphere where hydrogen is still a minor constituent, but that beyond this inner region hydrogen, because it is the lightest atom, will begin to predominate.

It would be of the greatest importance to find out what percentage of the gas is hydrogen at various altitudes, and what percentage of the gas is ionized so that we can evaluate the degree of ionization, the electric conductivity and the radio propagation properties of the outer ionosphere. Temperature of the gas and winds are of great interest and can be measured by the *Far Side* vehicle.

Earth's Magnetic Field

While the earth's gravitational field is the main controlling factor in this outer ionosphere of the earth, the earth's magnetic field is important because of its influence on the motion of charged particles, many of which come from the sun. First of all, one would want to measure the magnetic field itself to see if it falls off as the inverse cube of the distance.

It is hypothesized that there is an electric ring current flowing around the earth, with its maximum located in the equatorial plane at about seven earth radii (Fig. 6). The current would produce its own magnetic field, which is superimposed on the earth's field. One should perceive, therefore, a different dependence of the magnetic field with distance than is ordinarily calculated.

This ring current is thought to be responsible for the magnetic storms which are observed on the earth during periods of high solar activity. Magnetic storms give rise to radio communication disturbances so that their study is of considerable military and economic importance. Now for the first time, a direct examination of the causes of magnetic storms may be possible.

Cosmic Rays

The earth's magnetic field also greatly affects incoming charged particles. The highest energy particles are the cosmic rays and they are deflected by the earth's field so as to follow very complicated trajectories before they finally reach the earth.

At the equator, however, all except the highest energy particles are turned away by the magnetic field. Therefore, as we go out from the top of the atmosphere at the equator, we see an increase in cosmic ray intensity (Fig. 6). As the magnetic field becomes weaker with increasing altitude, it begins to admit the lower energy cosmic rays. In this way we can measure cosmic ray intensity as a function of altitude and ascertain the number of low-energy cosmic rays as compared to those of high energy, and therefore the energy spectrum of cosmic rays.

A particularly interesting question relates to the presence of very-low-energy cosmic rays. They are normally not observed near the earth although they could come in near the poles, where the magnetic lines of force are vertical and offer no resistance.

If these low energy cosmic rays exist in interplanetary space, we should observe an increase in cosmic ray intensity beyond three or four earth radii.



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However, if they are absent, the intensity will flatten beyond that altitude, as shown in Fig. 6.

The *Far Side* experiments could settle this important question. In addition they would give data on the space intensity of cosmic rays, one of the important quantities for space flights.

Auroral Particles

Apart from the cosmic rays, the earth's magnetic field has even greater control over the auroral particles, probably high speed protons, which enter the upper atmosphere near the poles to produce the luminous aurora. The *Far Side* vehicle would be able to establish what region of space these particles occupy and could explore this region by shooting through it.

Very likely magnetic lines of force confine the particles to a narrow band in the auroral zone; but if one goes high enough, one should run into the auroral particles even at the equator Fig. 6).

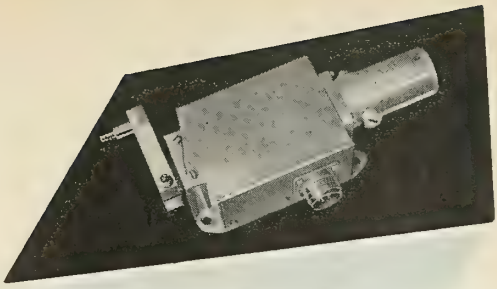
Such measurements would be of tremendous importance for geophysical theories. One of the outstanding problems is how these particles acquire the necessary high energy to penetrate so deeply into the atmosphere. Probably some kind of acceleration mechanism operates close to the earth, but its exact nature has not yet been determined.

Interplanetary Dust

It may even be possible to check the influence of the earth's magnetic field on larger particles, e.g., interplanetary dust. Current theoretical ideas predict that dust particles will be highly charged by the photoelectric effect of the sun's ultraviolet radiation. In that case, the earth's magnetic field should act on dust particles in the same way as on cosmic rays. One should, therefore, observe an increase in the number of dust particles as one ascends at the equator to higher and higher altitudes similar to that shown in Fig. 6.

Significance of Experiments

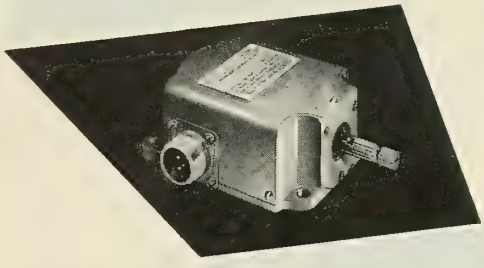
Aside from their scientific interest, such measurements as will be possible through *Far Side* are important because they give us some firm figures on the properties of interplanetary space and on the intensity of various radiations in the vicinity of the earth. For example, even though the outer ionosphere can to a first approximation be described as a vacuum, the small amount of ionized gas present there may be of considerable concern to vehicles which navigate this region since it affects radio propagation. Furthermore, the electric charge of a vehicle is controlled by the electron density in its vicinity.



The rotary actuator above incorporates an electrically operated clutch which will permit either free rotation of the crank, or will engage the motor and gear train to drive the crank.

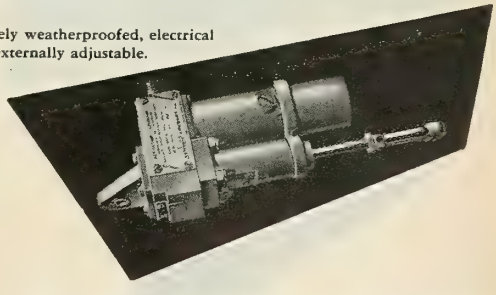
A built-in damper of the newly adapted eddy current principle resists input forces in proportion to input speeds when the crank is de-clutched and free to rotate.

This unique damper is also used in the magnetic brake below. The input shaft becomes locked to resist torque up to 200 inch-pounds when the brake is electrically de-energized. When the brake is energized, the input shaft is unlocked and the damper controls the input forces.



The linear actuator below, was designed and built to provide reliable electrical actuation in an environment of violent centrifuging and vibration. This unit weighs *less* than *1.5 pounds*, yet is capable of operating against opposing loads of *over 100 times* its own weight.

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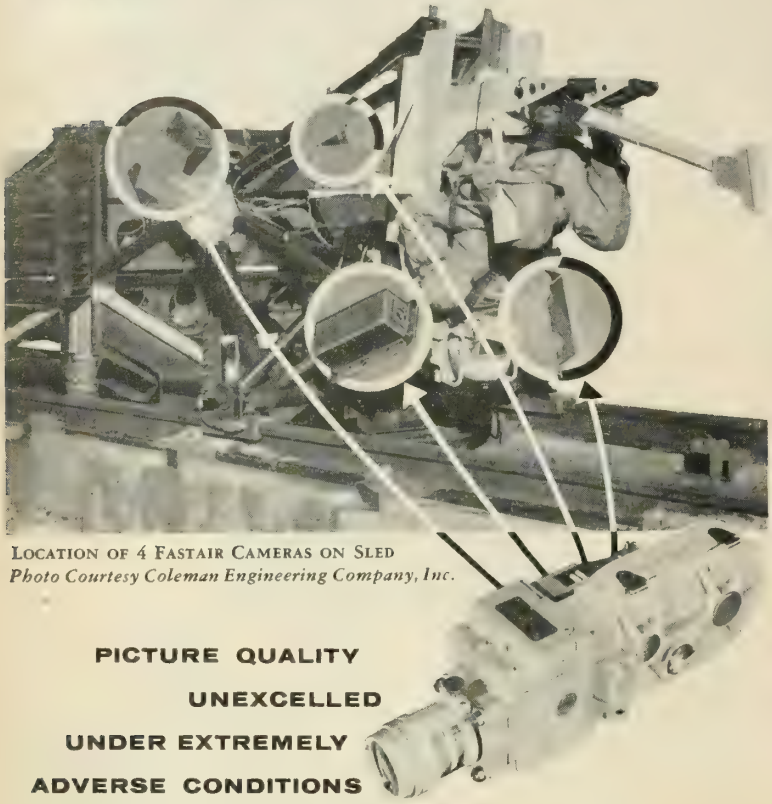
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Long Time Exposures

Another unique advantage of the *Far Side* vehicle over ordinary rockets is the long time spent above the atmosphere. In this respect it resembles the earth satellite and, in fact, its applications are similar, e.g., the *Far Side* vehicle can be used to observe the solar ultraviolet and X-rays for time periods in the order of hours. Should unusual conditions such as solar flares develop during the flights, this information will, of course, be detected by the instruments and telemetered to the ground.

Flight-time is also important for certain equipment which requires long exposure, such as cosmic ray emulsions used to detect the small flux of heavy nuclei in the primary cosmic radiation. Balloons have the disadvantage of operating within the atmosphere, but an emulsion carried in the *Far Side* vehicle will receive a long exposure in free space.

Recovery

Cosmic ray emulsions must, of course, be recovered; so must many other small scientific payloads exposed at these extreme altitudes.

Of great interest to space-medical research are exposures of small organisms, such as fruit flies or seeds, to the intense cosmic radiation which exists at these high altitudes and to any of the other radiations present. Until now no exposures have simulated exactly the high-intensity flux of heavy cosmic-ray primaries which exists in outer space.

The prospects of designing a reentry body for the *Far Side* vehicle look very promising, in spite of the small payload allowed. The reason is that the important scientific questions of just what happens when a high-speed body re-enters the atmosphere have now been solved in connection with ICBM programs, and special materials, possessing desirable characteristics at high temperatures, are now perfected.

Recovery of scientific payloads, entering from a 4000-mile altitude with satellite velocity, will undoubtedly be one of the great pioneering achievements of aerophysics technology. It will provide proof of the important scientific applications which can be derived from the current research in the military missiles field. More than that, the successful demonstration of extreme altitude recovery will open the way to more ambitious projects in the recovery of larger payloads, until eventually a manned vehicle is successfully re-entered into the atmosphere.

In more than one sense, therefore, Project *Far Side* is our first thrust into space and an important step in the development of America's spaceflight program. ★

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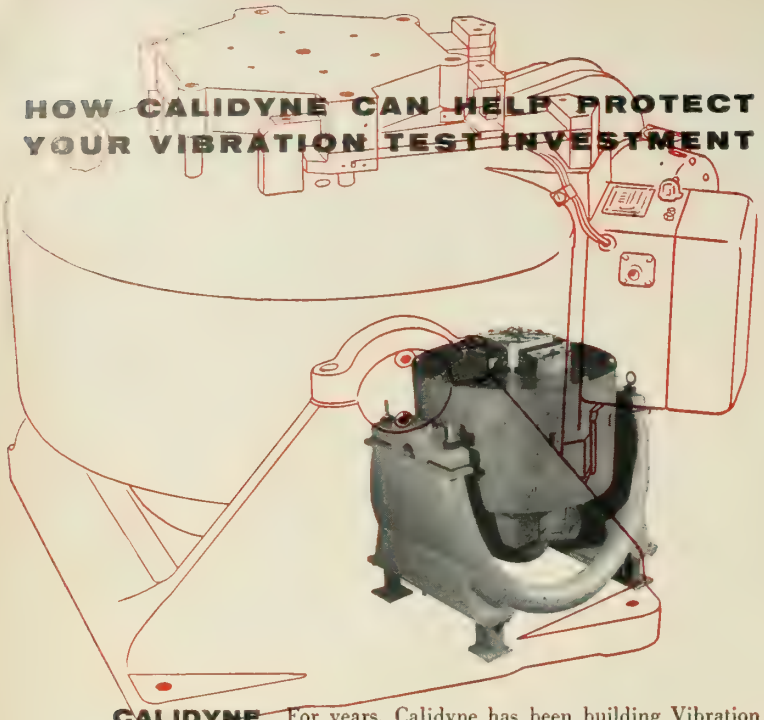
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industry briefs

Breakthrough on *Titan* Scored by Avco

A major theoretical breakthrough on the *Titan* ICBM nose cone has been scored at the Avco research laboratory. The company, which has a contract for the missile's nose cone totalling more than $111 million, has used shock tube experiments and X-17 flight tests for the principal sources of such data.

Security restrictions have prevented disclosure of the exact nature of the breakthrough, but it is known that the problem of heat transfer to the nose cone itself is understood and that the laboratory has constructed prototypes of the nose cone for *Titan* embodying these new concepts. They have the shape now considered feasible for the ballistic missile.

Waste King Organizes New Technical Division

Waste King Corp. has announced consolidation of three manufacturing operations and its advanced engineering and development arm into a new Technical Products Division.

The new division will develop and manufacture mechanical components and assemblies for guided missiles, precision machining of experimental missile and rocket parts and production of complex systems assemblies.

Garrett Builds Missile Valves

Phoenix, Ariz.—Garrett Corp.'s AiResearch Mfg. Co. has opened a new controls building for full scale production of controls for gases and liquids. The plant has about 500 employes working on valves for *Atlas*, *Titan*, *Thor*, *Regulus* and *Bomarc*. Some controls produced are designed for operation at temperatures up to 1000°F near absolute zero.

The completely refrigerated plant is of concrete block and its 40,000 square feet of floor space increase the company's Arizona division to over half a million square feet.

Navy SPR Drone Successfully Tested

The Navy's rocket-powered target drone, the XKDT-1, has been successfully flight-tested at the Naval Air Missile Test Center at Point Mugu. The missile-shaped drone is intended to sharpen the eye of Navy fighter pilots and operates near the speed of sound at altitudes up to 50,000 feet.

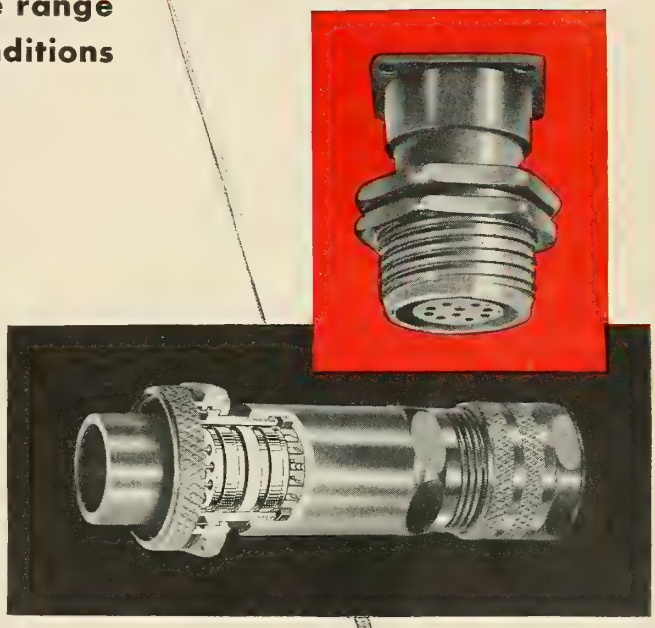
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NATO Budgeteer Holcombe

Points up how quarter billion dollar European missile market operates

John L. Holcombe is Director, Office of Programming and Control, International Security Affairs. Previously he was Deputy Controller for Europe under Lord Ismay and reporting to Assistant Defense Secretary W. J. McNeil. Probably more than anyone else he knows the basics of Europe's defense needs.

Q. *Can you give us a measure of the NATO missile program over the next several years?*

A. It would be misleading to speak of a NATO missile program since each NATO country is responsible for the logistic support of the forces it contributes to the NATO defense effort. Several of the countries are undertaking missile development. While there is concentration on surface-to-air missiles, efforts are also being devoted to surface-to-surface, air-to-air and air-to-surface missiles.

Q. If there is no NATO missile program, have the NATO military authorities taken a position with respect to missiles?

A. The most complete public statement on this followed the Annual Command Post exercise conducted from April 15-18, 1957. Then, Deputy Supreme Allied Commander Europe, Field Marshal Viscount Montgomery, stated that by 1966 we will be in the missile age. NATO strategy, he said, is built on the philosophy of the deterrent. In carrying out their task, the NATO military authorities must be careful not to plan the next war in terms of the last.

Q. How does Field Marshal Montgomery see the next ten years in missiles?

A. I can give you his exact words:

"Strategic missiles fitted with nuclear warheads. The expense and lack of accuracy of ballistic missiles make them unsuitable vehicles for less powerful explosives.

"In some weapons systems, guns will have begun to be replaced by missiles and rockets, e.g., antitank and antiaircraft.

"Short-range guided missiles with ranges up to 500 miles will be available in quantity.

"Intermediate-range ballistic missiles, with ranges up to 2000 miles, will be available and operational from fixed positions from land and ships.

"Man-made satellites will circle the earth.

"Intercontinental ballistic missiles, with ranges up to 5000 miles or more."

Marshal Montgomery considers that while there always will be a need for efficient strategic air forces to provide flexibility and to locate interior targets, the number of aircraft required for interception tasks will be reduced as the effectiveness of air defense by missiles increases. He also considers that piloted aircraft will be needed for limited and cold war activities.

Q. Does Montgomery consider that missiles will solve all the military problems of the Free World?

A. Indeed not. He recognizes that there are many troublesome problems connected with missiles, of which many are technical. Some of the present-day missiles are slow and can be intercepted, and guidance systems can be jammed, which reduces accuracy as the range increases. The ballistic missile is yet to achieve high precision, so that for real accuracy reliance must continue to be placed on piloted aircraft.

Q. What is the United States doing to provide missiles to its NATO allies?

A. Such weapons are included under the Military Assistance Program, including guided and free-flight missiles. Since the United States is the only nation of the Free World producing substantial quantities of missiles at the present time, it is essential that the United States provide missiles to our allies to match the growing strength of Soviet forces, which are being progressively armed with similar weapons. The NATO forces in continental Europe might not long survive a major assault if the United States contingent were the only forces armed with modern weapons, including missiles. Our allies cannot maintain their vital contributions to the common defense if their armed forces are inferior by reason of outmoded weapons.

Q. To what extent is the United States furnishing its allies with advanced weapons?

A. Through Fiscal Year 1957, the United States had programmed $410 million for new weapons, including missiles. Not all of this is grant aid, however. Approximately $136 million represents sales of equipment to Germany and other allied nations. Additional funds will be used in Fiscal Year 1958 to provide new weapons on a grant-aid basis and new weapons will continue to be offered for sale.

Q. What missiles are being made available by the United States?

A. *Nike*, *Matador* and *Honest John* missile systems are among the advanced weapons being furnished.

Q. Roughly what percentage of the $410 million is for missiles and related equipment?

A. Roughly half.

Q. Are we doing anything to provide them with United States missile production know-how?

A. There is now in the United States a team of Italian military and industrial technicians visiting military production and testing facilities. Similar teams from other countries are expected in the future.

Q. Is this the kind of assistance that Secretary Wilson referred to at the December 1956 meeting of the NATO Council?

A. Yes. At that time the Secretary of Defense announced two important steps being taken by the United States to provide NATO forces with modern weapons. The first, already mentioned, is that the military assistance program now includes deliveries to the other NATO forces of certain new weapons heretofore furnished only to the United States forces. The second is that the United States is prepared to make available certain new weapons systems

and equipment, together with appropriate technical data, to those of our allies who are willing and able to utilize them for developing their own modern weapons systems.

Q. Can you break down for us the mechanics of planning and programming missiles capabilities of the NATO powers?

A. The need for modernization of the NATO forces has been studied by SHAPE (Supreme Headquarters Allied Powers in Europe), and SHAPE has stated a list of requirements. These requirements have been reviewed by the United States military authorities, including the Joint Chiefs of Staff, to insure that SHAPE and United States planning are consistent. Because many of the items involved are, or have been, of a classified nature, the security authorities of the Departments of State and Defense have also entered the picture. On the basis of the requirements dveloped by SHAPE and reviewed by the JCS, the Department of Defense has programmed certain advanced weapons to be furnished under the Military Assistance Program. Also, the Department of Defense has indicated its willingness to consider the sale of certain items to those countries which have the economic capability to buy them.

Q. What are some of the ways in which the United States is encouraging European production and development of missiles?

A. Through the Mutual Weapons Development Program, established in 1953, the inventive capability of Western Europe is being added to that of the United States in the race to keep ahead in the development of new weapons. Bilateral agreements have been negotiated with the governments of the participating countries. This means the United States has the benefit of European know-how and vice versa. These technical argreements set forth the details of the projects and the responsibility of the participating country. They also serve as the basis for payment by the United States of specified amounts contributed to the support of the projects which are shared between the United States and the other nation. The results of MWDP projects generally will be made available for the benefit of all NATO countries. Included are projects for guided missiles systems, countermeasures, new and improved radar, etc.

Q. Are there other ways of encouraging European efforts?

A. If a country has a new weapons system that would make a genuine contribution to the NATO defense, it may be considered for inclusion in the Facilities Assistance Program. This is designed to assist the establishment and expansion of overseas facilities for the manufacture and maintenance of essential military equipment, including guided missiles. Projects presently under consideration include several missiles systems and projects for components. The capacity required for missiles propellants has already been established in Europe with the aid of previous projects.

Q. Does the European missile requirement vary materially from that of the United States? If so, how?

A. Yes, the NATO missiles requirements are different from those of the United States—geographical location; distances to potential targets; short warning time. For many tactical applications, however, the requirements will be similar.

Q. Is there any program under way or planned for a simple missile design and development competition in Europe similar to that conducted for the NATO Light Fighter?

A. Missiles are still in their infancy, whereas aircraft have been with us for a long time. It has not yet been possible to establish an environment that would make profitable international competition in missile design. The fact is becoming increasingly clear, however, that the complexities of missiles development and production, and the tremendous costs, will necessitate cooperative and coordinated efforts on the part of the various European NATO countries. This was also expressed by Secretary Wilson in addressing the NATO Council last December. The technical basis for such cooperation appears to be available, in that there are several simple effective systems in Europe. There seems to be an increasing need for coordinated effort, but this has not yet been achieved on a multilateral basis. There have been some bilateral arrangements, however, which are very encouraging.

Q. In programming for the integration of missiles in European defense, have you run into any major political troubles such as from Communist minorities or Soviet blackmail?

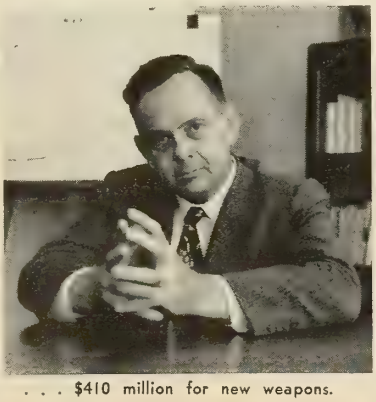
A. No problems involving Communist minorities have yet been encountered in programming missiles for the European defense effort. You are aware of the threats to Norway, Denmark and other NATO governments by the USSR and especially of the similar threats more recently against Western Germany. Such Soviet propaganda efforts can be anticipated against any efforts to strengthen the NATO defenses.

Q. Can you be specific in saying what the views of NATO planners are toward some of the European missiles as operational weapons, such as French, Swedish and British missiles?

A. Some of the European-developed weapons systems are very good. Since Sweden is not a NATO member, however, there is no knowledge of what may be under development in Sweden. The NATO planners encourage the development and production of missiles in Europe. The United States also encourages such efforts. Any data or information regarding European-developed missiles must be sought from the originating country. ★



For Europe in fiscal 1957 . . .



. . . $410 million for new weapons.

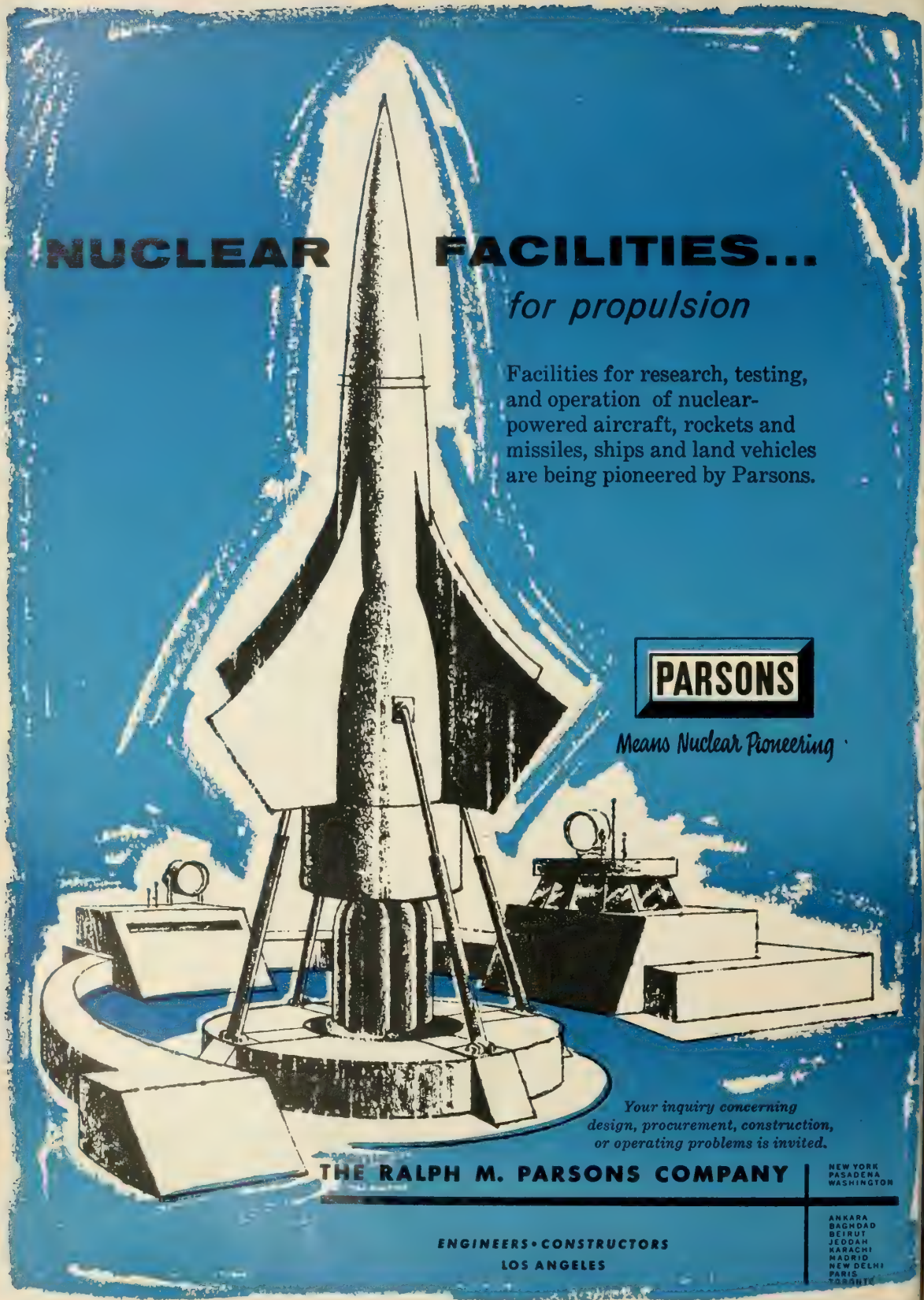


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Sectional Satellites

. . . a bit-by-bit approach to space flight

By Commander George W. Hoover, U.S.N.
Office of Naval Research

THE LAUNCHING of the first earth satellite during the International Geophysical Year will be only the first step in a very large research program to gather data which will eventually lead to manned space flight. Before man can venture too far beyond the protective blanket of the atmosphere many satellites must be launched and a vast amount of data must be gathered and analyzed to determine the design of a manned space ship.

As more and more information is sought, the satellites will tend to grow larger and larger, putting an increasing strain on the relatively small amount of power to be derived from presently known rocket propellants. The size of the boosters and each successive stage of the satellite vehicles will increase and the number of stages will multiply until we reach a point of diminishing returns.

Since there is a definite limit to the amount of payload that can be placed in an orbit with chemical rocket fuels, it might be in order to look at another possible way of gathering data over long periods. One possible solution might be a sectional satellite.

The paramount requirement for any satellite is to stay within payload limitations compatible with the power capabilities of rocket fuels in a system which remains small enough to guide and control efficiently.

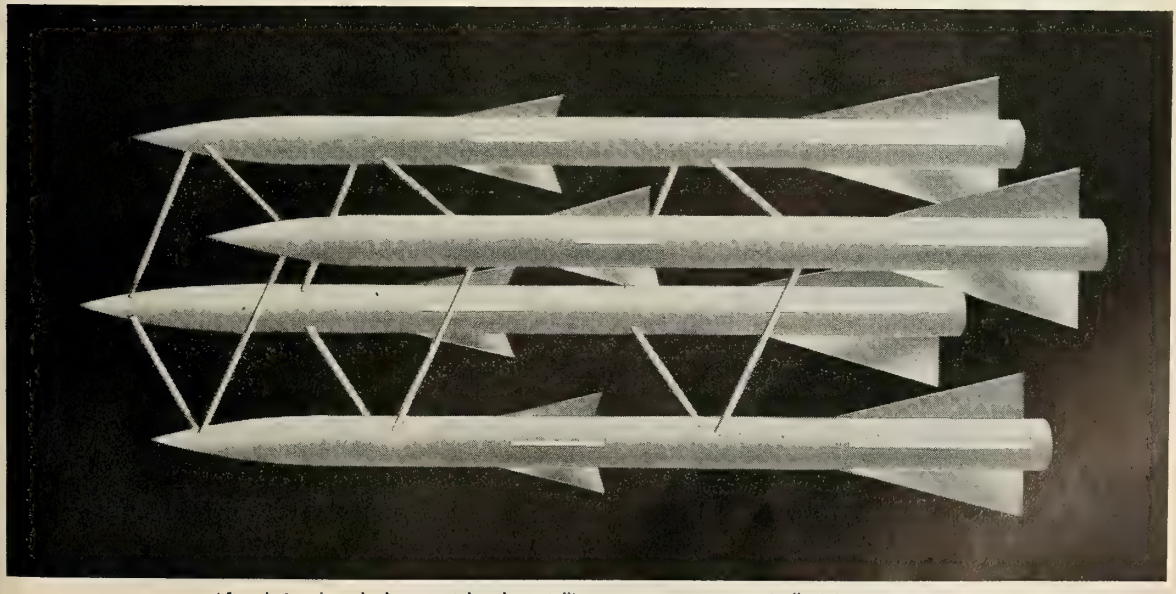
Additional requirements call for sending up sensors which are capable of sensing many kinds of information, such as spectrometers, cosmic ray and aurors counters, gamma ray counters, X-ray counters, meteor dust counters, telescopes and many many others. Some of it must be run through amplifiers and computers. All of it must be recorded.

From the recorder it must then be transformed into a signal which can be transmitted at proper intervals to the receivers back on earth. In addition there is the power requirement to operate these devices for very long periods. When the power source is depleted, the satellite will be of no further value except where ground observation techniques can be used. The satellite must also transmit position information.

In order to meet the above requirements it will be necessary either to build one very large satellite or a great many smaller ones. In the case of the very large one the expense will be monumental and such a satellite must be confined to measuring only the information which it was originally designed to gather.

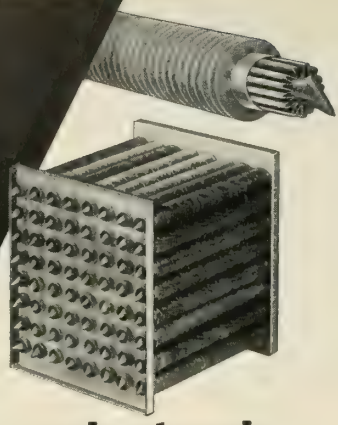
Even with a large power supply it will eventually run down with no possibility for replenishing the power source. Its greatest weakness, however, is a lack of flexibility.

In the case of a large number of

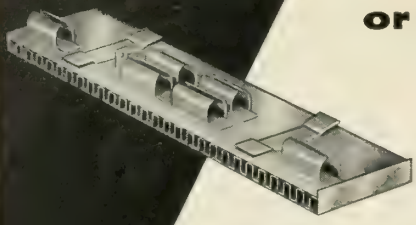


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small satellites, each one must carry the necessary components, sensors, computers, amplifiers, recorders, transmitters and power supply. The greatest weakness here will be redundancy without reliability. Each one will operate until its power supply is gone and then it will again be useless except for ground observation. Each will be able to gather only a little data because most of the payload will be used up in the transmitters, recorders and power supply.

Now let's go back to our requirements. First we need a relatively small payload to keep within economical size. This would indicate a large number of small satellites rather than one large one. Further requirements, however, call for many sensors but only one computer, one recorder, one transmitter and one power supply. Ideal satellites would permit addition of sensors as new data is desired and to replenish the power when the supply is run down.

One solution would be to develop a series of small satellites, each as a component in the total system. These components would be placed in the orbit and then connected together. This would permit using relatively small payloads, using the total payload in each unit for the component itself and would eliminate redundancy.

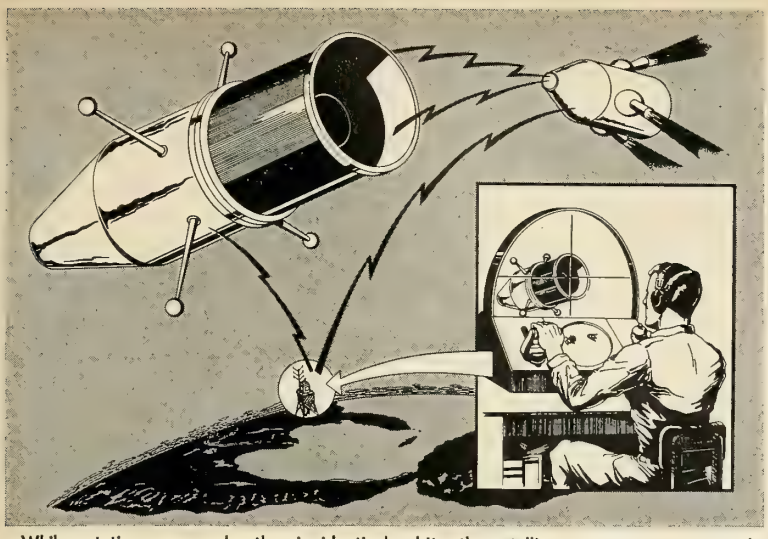
Doubling up on critical components would increase reliability. It would permit replenishing the power supply at any time; and with the proper design of connectors, it would permit flexibility by allowing new sensors to be connected when new data was desired. In addition the basic design of the components as well as the satellite vehicles could be fairly well standardized for large production, thus reducing the overall cost.

The problem of connecting the components could be achieved by one of several possible methods. One way might be to launch the components as a cluster in which each stage would be flexibly connected with other components in that stage. If there were five components to the system, five multistage rockets arranged in a cluster could be used to place the satellite components in the orbit. The flexible connections could be utilized to take care of deviations in trajectory during the firing of the multiple stages.

Such a method would require very good quality control of each of the components in order to insure simultaneous firing of each element in the cluster, but this would be well worth the advantages that could be derived from getting a much more efficient satellite into the orbit.

Many combinations could be used, such as: the elements could be rigidly

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While rotating near each other in identical orbits, the satellite components are joined together through the use of ground control stations using television cameras as "eyes."

connected using each component in the cluster as firing stage. The only difference here would be in the fact that the stages were arranged in clusters rather than in tandem.

Another method of establishing the connections of a sectional satellite would be to place each component into the same orbit but slightly to the rear of the preceding one. This would require extremely accurate launching in order that each successive section would arrive in the orbit at the proper time and in the proper position.

Errors in orbit could be corrected by using an infrared or magnetic homer which would also bring about the connection of the components. Each successive unit would require a slightly higher velocity in order to overtake the preceding one and some means would have to be included in the last firing stage of each of the satellites in order to clear the way for the payloads to connect. A small jet using compressed air would be sufficient for this action.

Much must be learned about placing satellites into orbits but with the state of the guidance art improving as it is, such a method is not impossible.

A third method would be to affect the connection of the units by ground control. Here the controller would get his information from the unit itself. Each unit would contain a small television or infrared sensor which would look forward at the tail of the preceding component.

By means of small compressed air jets controlled by a simple radio control from the ground, the approaching unit could be plugged into the orbiting unit in much the same way as aerial refueling is achieved. Upon connecting, the television camera could be set to realign itself in order to be used as an observation sensor.

All power to supply these units would come from the main power unit by means of a carefully designed hook-up circuit.

Each component could be added by the same technique until the entire system was assembled. The best order for assembly of the components would probably be to place the power source into the orbit first, the transmitter, recorder, amplifier and finally the sensors. Additional sensors and power supplies could be added as desired.

The employment of a man-controlled system would obviously be more flexible than any self-contained system and would probably come closer to meeting the overall satellite requirements. Since telemetering will be required in any case it seems much more efficient to make use of this means to control and connect the satellite.

Manned space stations will eventually be constructed but a great deal must be learned before this can become a reality. Sectional satellites can teach us how to construct these space stations while being utilized to gather scientific data. It may even be possible to construct the total space station by remote control by building the sections in a honeycomb arrangement and then placing each section into the orbit either in clusters or individually. Unmanned observatories could be built utilizing a sectional technique.

Thus it appears that a sectional satellite would meet the overall requirements for a sophisticated research satellite, accelerate the gathering of scientific data, teach us orbital construction techniques and bring the day of manned space flight just a little closer.★

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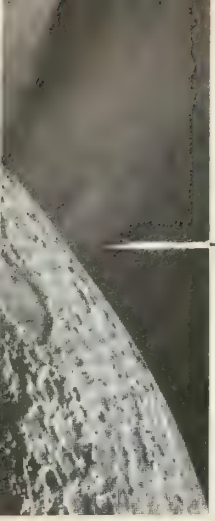
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missile miscellany

Something else seems to have happened to Vanguard. This page hears reports from people who are privy to the project's secrets that (a) the first stage with the dummy second and third still hasn't been fired, though it's allegedly been "ready" for a few weeks now; (b) that delay may involve alteration of fuel (magnesium or boron-plus-JP4 slurry) or oxidizer (flox) or both. If so, it could mean more delay and expense for the satellite project.

And this page heard and saw demonstrated by one of the World's top solid propellant experts how a dye marker could be landed on the moon within weeks for a total cost of less than $200,000. Heard also from another expert how bombs and rockets will be useless as weapons when launched from manned satellites, skip bombers and other space vehicles.

Then, there was the misdirected telephone call to extension 92658 at the Pentagon which was answered: "Good morning. Unconventional Warfare."

And speaking of changing times and difficult adjustments, let's look at tomorrow today—like *Jupiter,* for example, with the aerodynamic surface of a bullet and an all-welded aluminum skin, and Thor whose toy-tiny fins seem more a concession to habit than a functional necessity. Why fight tomorrow? It's here with more dollars than ever.

And for the day-after-tomorrow, a report, still untraced, of two positrons in a mutually destructive collision and simultaneous, momentary low-energy elimination of the local gravitic field. Whodunit?

Before the Red ICBM we were told that missiles would soon be IT. The airplane had a limited future. Now the Russians have the big bird, and the same people tell us missiles aren't all that good; that airplanes will be the mainstay for many years. Remember, too, how a few weeks ago the anti-ICBM was "years away" and now it's just around the corner? Uh-huh . . .

Now, about that 3000-mile super-radar—it's not all that close, nor necessarily practical. It requires: voltages heretofore achieved only in the laboratory; antennae as big as the Capitol dome; railroad tracks to direct it; a remote location so it won't cook everybody in front of it; and a nuclear power plant. Even then, it's line-of-sight and won't tell the instant an intercontinental ballistic missile is launched.

We're also told "but the Russian ICBM isn't operational." If it will carry a nuclear warhead to within a reasonable distance of a target 5000 miles away, it can be fired from the factory floor! It doesn't need complex mobile logistic back-up like small missiles.

And in case anyone thinks solid-propellant missiles won't get "all that big," this page recently learned of a tooling requirement for a precision lathe with a 140-inch swing and a bed over 45-feet long, center-to-center, needed for finish work on large solid-propellant motor now in design and prototype test stage.

Hawk will be the drone for Hawk. Motorola's revolutionary pulse-light guidance system will keep bird an even 50 feet over any terrain at high supersonic speeds. Hawk, incidentally, is a two-stage vehicle.

Grand Central Rocket Co. has a small rocket-carrying borate solution for fighting brush and forest fires . . . And a sign in a large missile-development laboratory: "We can do it—what is it? We did it—what was it?" . . . 100,000-pound capacity static test stand is going up on one of the islands in the Detroit river . . .

Underwater missile tests are being conducted in Lake Erie . . . Towed models of special hull on West Coast have shown a drag reduction of 80% . . . which makes 60-knot submarines and 600-knot underwater missiles closer to being more than just talk . . . Growing support is noted for very small, high-speed solid-propellant underwater missiles fired in salvo, like 2.75-inch air-to-air rockets; their mission: puncture enemy subs' hulls . . . Navy has turned down small high-speed interceptor-type anti-sub sub as "unnecessary"—eh? . . .

Now a report this page hears of super-hush-hush meeting of nation's top scientists in Old State Department building. The question they ponder: How can this country be defended—from missile-launching subs lurking 15 miles off shore, Red ICBM's, H-bombs, anti-missile-missiles, anti-anti, etc.

Shades of confusion—because of improper liaison between launch-site builders and missile-makers, missiles couldn't be fitted into many of the Nike launch sites. And, antipodally speaking, proof that Japan admires American ways: Japanese Air and Ground Self-Defense forces are raising Nipponese Ned about who should have control of guided missiles. Then, there's the U.S. Vanguard propulsion expert who suggests that if Red ICBM is patterned after Vanguard, it won't work—he probably forgets that the twin-jet Bison bomber couldn't fly either, but does; that the Reds traditionally get a lot more thrust out their engines than we.

And a bitter question: With so much money going for R & D on officers' white dinner jackets, runway vacuum cleaners, etc.—stuff industry should do on its own on competitive basis—why slash basic weapons research?

And out of Redstone Arsenal and ABMA, official insistence that Jupiter be called the Air Force Jupiter and an anticipatory enthusiasm for becoming an AF ballistic missile subcontractor.

At right—wonder what this would do to solid-propellant rocket's specific impulse . . .



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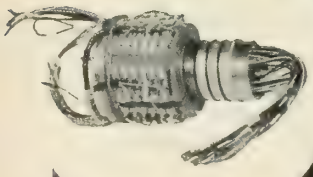
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Space Medicine

By Hubertus Strughold, MD., PhD.

The high-altitude balloon flight of Maj. David G. Simons was a great event in space medicine. This record 32-hour flight, Aug 18th to 20th, with altitude peaks up to 102,000 feet, has demonstrated that man can exist in a sealed gondola filled with an artificial atmosphere and surrounded by an environment which is to a very high degree equivalent to free space.

With regard to air pressure and its functional significance for the human body, the altitude reached is almost the same as the near-vacuum of interplanetary space. This flight, with a plastic balloon developed by Otto Winzen Co., is indeed a breakthrough on the vertical frontier. Behind it were several years of meticulous scientific and experimental preparation. It will be remembered as a heroic scientific and major engineering achievement in the history of human flight. Our congratulations to Maj. Simons, to Col. Paul Stapp of the Aeromedical Field Laboratory and Mr. Winzen.

•

The School of Aviation Medicine, under Maj. Gen. Otis O. Benson, will conduct a three-day symposium in San Antonio on Physics and Medicine of the Atmosphere and Space during the first half of November 1958, the end of the International Geophysical Year. About 40 papers will be presented by physicists, astronomers, engineers and medical doctors from the U.S. and abroad.

•

The American Rocket Society's Human Factors Section, headed by Major D. G. Simons, will have a session at the annual meeting of ARS in December in New York. The writer of this column will be chairman of the meeting.

•

The study of the solar-terrestrial relationship, which is high on the list of the IGY program, is of special interest from the space medicine point of view. Solar flares, for instance, lead to an enormous increase in cosmic radiation. In a paper published in the August issue of the JOURNAL OF AVIATION MEDICINE, Dr. Herman Schaefer of the U.S. Naval School of Aviation Medicine, Pensacola, Fla., reports on the Cosmic Ray Dosage During the Giant Solar Flare of February 26, 1956.

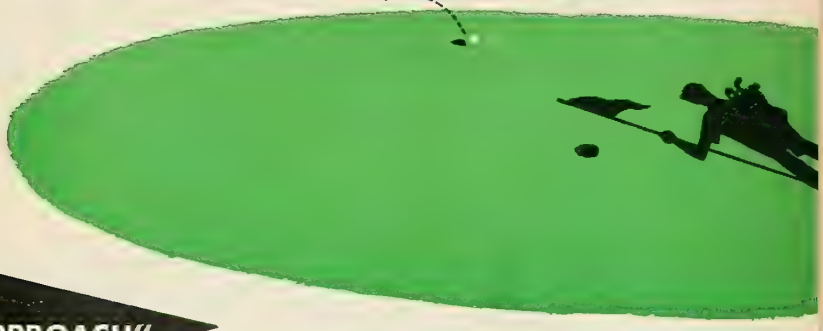
His calculations, based on the sea level influx of neutrons, indicate that in the middle latitudes—twenty minutes after the visible flash of light on the sun—cosmic radiation in the estra-atmosphere regions increased suddenly to very high intensities (about 1000 times greater than normal) and then gradually returned to normal within about eighteen hours. A similar strong solar eruption was observed at the beginning of the IGY.

•

Dr. Syrrel S. Wilks of the School of Aviation Medicine has discovered that green plants like algae, proposed as a source of food and oxygen in space flight, give off deadly carbon monoxide gas. The Randolph Air Force Base pysiologist says this might raise a problem for future space-ship occupants.



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INDUSTRY SPOTLIGHT



By Norman L. Baker

Thiokol Scores Major Breakthrough in Solid Motors

MARSHALL, Texas—The development of the *Nike-Hercules* sustainer motor, currently in production at Thiokol Chemical Corp., Longhorn Division, was the result of a major breakthrough in solid motor design.

Propulsion units for *Falcon, Lacrosse, Hawk,* and the *Nike-Hercules* sustainer are currently in production here. Although few details have been released about the latter system, there have been a number of interesting disclosures. A photograph of the sustainer unit shows a bottle-like motor which necks down to a long blast tube. At the end of the blast tube is a conventional nozzle. The reasons for these configurations are twofold: (1) to have the center of gravity as far forward as possible, (2) to give an annular space for controls around the blast tube.

Thus, it appears Thiokol has scored two major breakthroughs: ducting the extremely hot gases for a considerable distance and insulating against these temperatures for long burning times. The thrust level, too, is quite high as evidenced by the long flame emerging from the nozzle mouth during firing tests.

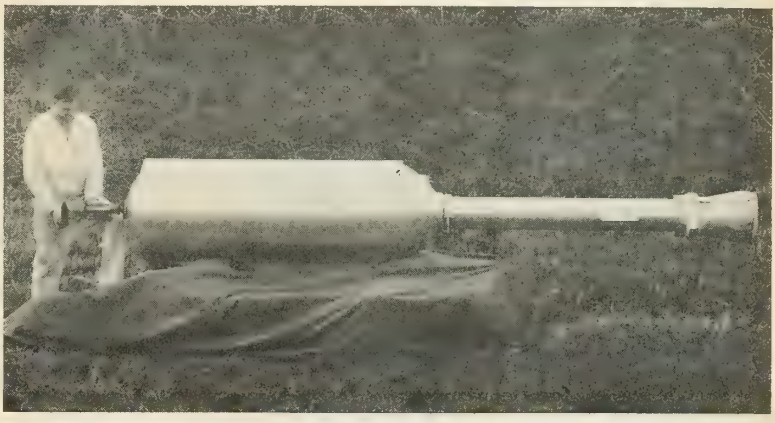
The long-burning-time motor is uncooled and is successful because of insulation techniques. This insulation material is probably furnished by Haveg Industries Inc. Machined parts are supplied by Goodyear and Borg Warner.

The motor, which can be touched with the hand immediately after firing, is so little affected by heat that during development several firings have been made by reloading the same hardware. The booster for the *Nike-Hercules* consists of four standard double-base solid-propellant *Nike-Ajax* booster motors.

Under a $5-million expansion program, the Longhorn Division is being expanded. This contract has recently been extended through 1959 and it is anticipated that the Ordnance Corps will make additional demands on this corporation. Rocket facility was designed by Thiokol in 1953 to produce a large volume of small solid rockets such as the *Loki* and a two-inch air-to-air rocket. The plant was put into operation in 1955. Now, with the trend toward a small volume of large solid rockets, production thinking and techniques have had to be revamped.

In 1956, some 800 persons were employed at the Longhorn Division which is located at Karnack, Texas. In addition to the rocket facility, Thiokol is responsible at Longhorn for maintaining a TNT plant in standby, and a pyrotechnics plant in layaway, ready for use as required by the Department of Defense.

For security reasons Thiokol has not released production figures, but production capacity in 1953 was estimated at about one-half million pounds per month, and it is believed that current capacity is several times that. The primary purpose of this Thiokol-Texas facility is production, although a certain amount of development is carried out. In this regard, The Thiokol Division works closely with Thiokol-Redstone Division and with the two company-owned divisions of Elkton, Md. and Brigham City, Utah.



The NIKE-HERCULES sustainer motor is an uncooled and long burning unit. Success of the motor is due to advances in insulation techniques by Thiokol and Haveg Industries.



The long flame produced during a static firing of the NIKE-HERCULES sustainer motor is indication of a high thrust level. Cooling is so effective motor units may be re-used.

Rocket Exhaust Flame Drills Rock

The rocket exhaust flame is now being put to industrial use. On the gigantic St. Lawrence Seaway project, blast holes are being sunk in rock with a rocket flame process known as Jet-Piercing. Developed by Linde Co., Division of Union Carbide Corp., the new process works on the rocket principle and makes it possible to pierce rock at speeds up to ten times faster than conventional drilling methods.

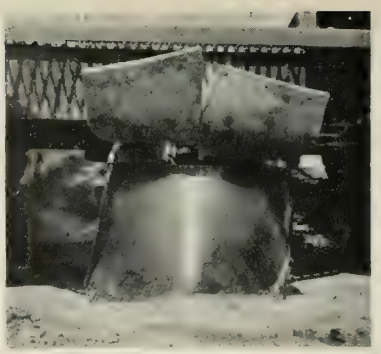


The Jet-Piercing rig is fed 10,000 cu. ft. of oxygen and 40 gal. of fuel oil per hour. Oxygen is supplied from a trailer holding enough for eight to ten hours operation.

Intensely hot, supersonic jets of flame are the key to the new process. Reaching temperatures of 4000°F, the flame spits out of a rocket nozzle and disintegrates or spalls the rock in its path. This is a continuous operation. Disintegrated rock particles are thrown up out of the hole by the combined force of burning gases and steam so that a fresh surface is continually exposed to the jet flame. The only limitation to penetration depths is the length of the hoses (carrying fuel, oxygen, and water) that are lowered into the hole. Deepest penetration obtained to date is 160 feet.

The rocket flame represents one of the highest concentrations of energy available to man. At its highest velocity, flame has a mechanical energy equivalent of about 500 horsepower—yet this energy is contained in a flame not more than 18 inches long and two inches wide.

Low viscosity fuel oil or a liquid hydrocarbon fuel such as kerosene is combined with high-purity oxygen to produce the intensely hot flame. A blowpipe, suspended from a crawler-carrier, controls flame combustion and action.



The 4000° rocket exhaust flame begins to cut.

Linde has found that their new process works fastest on the class of spallable rocks which normal drilling methods find toughest—especially those containing silica—such as granite, syenite, quartzite, sandstone and magnetic taconite. Potsdam sandstone, the rock being pierced on the St. Lawrence Seaway, is a highly abrasive material that would normally cause excessive bit wear. In the past it has taken as long as a week to drill a 100-ft. hole in this



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very hard rock using churn drills. But with jet-piercing, a 100-ft. hole can be sunk in a single shift.

In addition to the increased speeds of penetration, Linde's Jet-Piercing process makes it possible to "chamber" blast holes. Chambering consists of enlarging the blast hole at any desired depth so that extra explosive charges can be placed exactly where needed. The operator simply lifts the blow-pipe off the bottom of the hole and lets the jet blast away.

Since Jet-Piercing harnesses thermal energy instead of mechanical energy, the new process also eliminates the maintenance problems associated with churn drills, pneumatic drills, and jackhammers.

AF Seeks More Seattle Space for Boeing

The Air Force is trying to get more space for Boeing's pilotless-aircraft division in Seattle. The Army Engineers' headquarters installation there has been tapped for the space, and a decision on the request should come out of Washington. Air Force has also obtained government warehouses across from the Engineers' HQ for its Boeing-Support program.

AP&C is Sole Producer of Solid Oxidants

The production of the solid propellant oxidants, ammonium and potassium perchlorate. is the sole responsibility of the American Potash and Chemical Corp.'s Henderson, Nev., plant. Production capacity is in excess of present and foreseeable defense requirements. Production will step up on completion of a new plant in Aberdeen, Miss., currently in the planning stage.

Products manufactured at Henderson are sodium chlorate, potassium chlorate, potassium perchlorate, ammonium perchlorate and manganese dioxide.

The chlorate and perchlorate processes start with the electrolysis of salt trucked from a deposit approximately 90 miles away in California. The primary product, sodium chlorate, is sold commercially and used as a raw material in making perchlorates.

The perchlorate process involves electrolysis of sodium chlorate solution at a platinum anode to produce sodium perchlorate. This is in turn reacted with potassium chloride to produce potassium perchlorate in a company-owned facility, or it is reacted with ammonia and hydrochloric acid to produce ammonium perchlorate in a Navy-owned plant.

The company-owned sodium chlorate facilities are capable of producing considerably more than would be required to run the perchlorate plants at maximum capacity. In addition, the Navy owns sufficient cells to produce approximately 600 tons of sodium chlorate per month. Approximately one pound of sodium chlorate is required to make one pound of potassium or ammonium perchlorate.

Currently sodium perchlorate capacity is approximately 1000 tons per month. There is ample space to install additional cells to bring the monthly capacity up to 1500 tons.

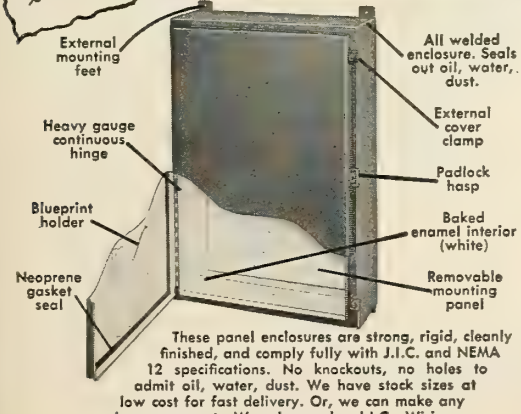
The Navy-owned ammonium perchlorate facility is an integrated unit built on land owned by the Navy adjoining the American Potash plant. Sodium perchlorate is piped to it in slurry form. Power, water and other services are provided by American Potash.

The capacity of this plant is 1200 to 1500 tons of ammonium perchlorate per month for a maximum of 18,000 tons per year. Ammonia is brought in by rail from California producers and hydrochloric acid is supplied from an

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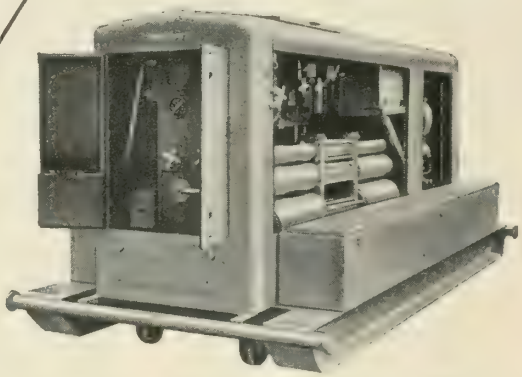
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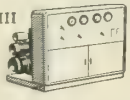
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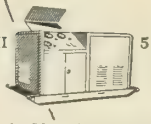
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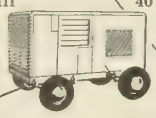
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adjacent plant at Henderson.

The Henderson plant is capable of producing either ammonium or potassium perchlorate or any ratio thereof up to the total capacity of 1200 to 1500 tons per month.

APCC is also engaged in the production of lithium perchlorate. This is only one of the products from their lithium chemical products facilities.

Present price schedule for ammonium perchlorate is in the range of 40¢ to 45¢ per pound, depending on the grade and quantity involved. Increased production would drop these figures substantially.

Current price schedule on ordnance-grade potassium perchlorate, grade suitable for solid-propellant systems, ranges from approximately 25¢ to 30¢ per pound.

In order to further expand their knowledge and technique in the solid-fuel oxidant picture, APCC recently acquired National Northern Corp. of West Hanover, Mass., where large scale facilities are maintained for research, development and production contracts for rocket power development.

Propellex Moves Up In Solid Propellants

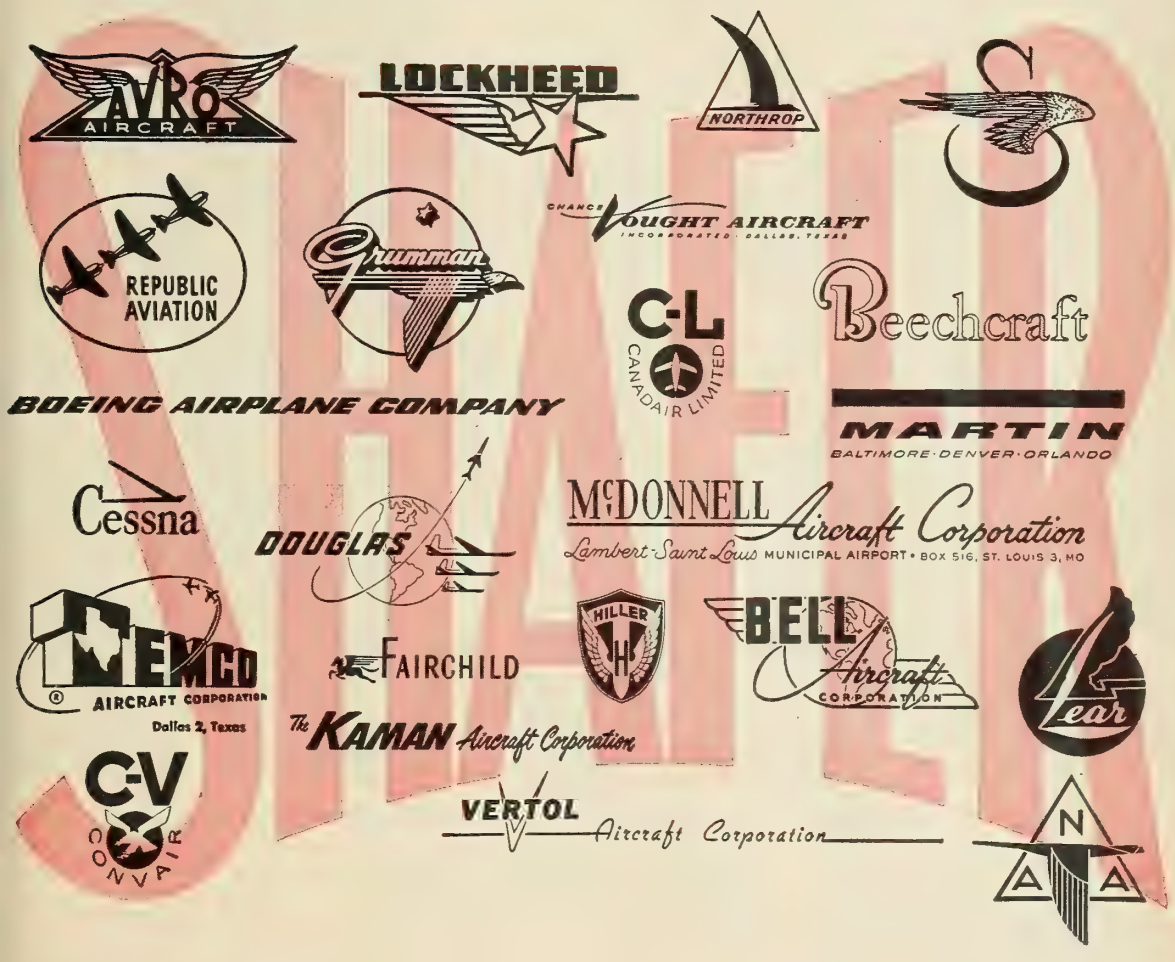
EDWARDSVILLE, Ill.—Starting from a basement operation in August 1956, Propellex Chemical Corp., headed by Robert A. Cooley, has moved into its new 100-acre facility located near East Alton, Ill. The security area, comprising about 15 acres, houses an administration and engineering building, plus six other buildings for solid-propellant operation. Buildings house materials storage, mixing, and assembly areas and are well spaced for safety.

Propellex will do research, development and production of solid-propellant devices ranging from gas generators to rockets. The firm is already producing several cartridge-actuated devices. Especially interesting is the Propellex-developed cartridge-actuated landing gear system which takes the place of hydraulics or high-pressure bottles and connecting high-pressure tubing.

Estimated capacity of Propellex is about one-million pounds of solid propellant per year. The facilities will now permit casting solid grains of about 250 pounds. Primary emphasis will be on solid propellants of all types—cast double base, ammonium-perchlorate composite, and ammonium nitrate. Work on fuel binders is underway and a low-energy ammonium-nitrate propellant is "in the works" while a high-energy type—possibly mixed with double base—is also anticipated.

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of new solid-propellant advances and rapidly translate them into hardware.

Other operations of Propellex include: preparation of igniter and delay mixes involving zirconium, novel chemicals for heat sensitivity applications and the nitration of special organic chemicals for use in solid propellants.

NAA to Produce New AF Missile

The Missile Development Division of North American Aviation has been selected by the Air Force to produce a new long-range bombardment ASM. According to NAA, organizational ability was one of the chief factors for its selection by the Air Force for the new project.

The company's proposal was selected for its superiority in technical concept and its proposed managerial plan for carrying out the development on a timely basis. The division has responsibility for the weapons system and will have high-priority support from other NAA divisions during the project.

Aeronca Receives *Atlas* Contract

Aeronca Manufacturing Corp. has signed a contract with Convair-Astronautics for a design study program on the *Atlas* ICB. The contract provides for a study in the application of materials in the design and fabrication of the *Atlas*, now in pilot production at Convair.

The initial Aeronca program will cover several months of research and development work at both the Middleton and Baltimore research divisions, and will include application and environmental testing. Aeronca is in the midst of a transition from conventional airframe production to weapons subsystem production.

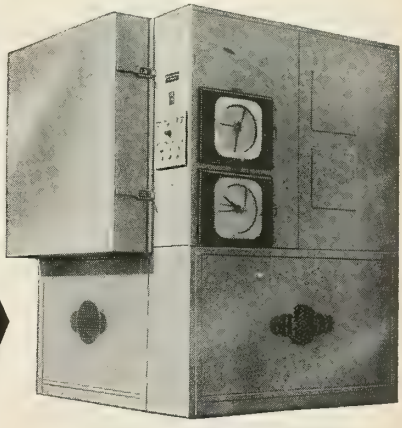
Lockheed Investigates Nuclear Power for Missiles

Nuclear power to propel missiles of the future is under serious investigation by Lockheed Missile Systems Division scientists. Dr. Louis N. Ridenour, assistant general manager for research and development, revealed that nuclear propulsion studies will be further advanced with a powerful new atom smasher which went into use this week at the Lockheed nuclear laboratory, one of the facilities of the missile division's research and development center located in Stanford University's Industrial Park at Palo Alto, Calif.



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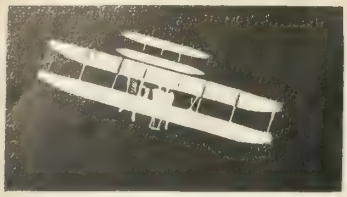
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West Coast Industry

By Fred S. Hunter

No secret is Lockheed's great desire to establish itself solidly in the electronics field to round out its missile systems division. Not so well known is the fact that it also has its eye on the propulsion field. Senior Vice President Hall L. Hibbard let this cat out of the bag in addressing a management club meeting in Palo Alto, where he told the MSD supervisors the division must get into propulsion.

Power ties in so closely with missiles that propulsion systems should be tailored for each individual weapon, Hibbard said. He pointed out that there have been no really new inventions in missile power that have amounted to anything since the start of missile developments. Liquid rocket engines are simply refined V-2s, he added.

"We haven't scratched the surface in getting energy," Hibbard stated—a broad hint as to Lockheed's course in its propulsion development efforts.

•

It's likely the Air Force will pick P&W's new J52 turbojet engine for the air-to-surface missile for the B-52 to be developed by North American Aviation. Another possibility is two General Electric J85s, but there's less chance for engine failure with one engine than with two and this is a critical factor for an ASM operation. The J52 is a Navy engine, but the Navy undoubtedly would be only too happy to let the Air Force come in for a share of the development costs.

Interesting sidelight of NAA's planning is the shift of Dale D. Myers from chief engineer of the Missile Development Division to project manager on the ASM. One of the factors which won the ASM competition for NAA was its proposed managerial plan for carrying out the development expeditiously.

•

Radioplane's new XQ-4A supersonic target drone, for which it has an Air Force development contract, is a higher performance vehicle than the XQ-4, incorporating a new engine. The needle-like XQ-4 has made a number of quite successful flights in the test program that should be running just about now at Holloman Air Force Base and has set the stage for the new model. The XQ-4A is not a training drone; it's designed for use in evaluating weapons systems.

•

One outward difference between the Rocketdyne test stands at Santa Susanna and Neosho is the sheet metal siding used on the stands in Missouri. That's to permit all-weather operation. The weather in California is, of course, always balmy so the Santa Susanna test crews have no need for this protection . . . This reminds that lately Rocketdyne has been teaching Joplin and Fort Crowder firemen how to handle liquid oxygen. LOX for Neosho's test operations is shipped by rail to Joplin and then to the test area by truck.

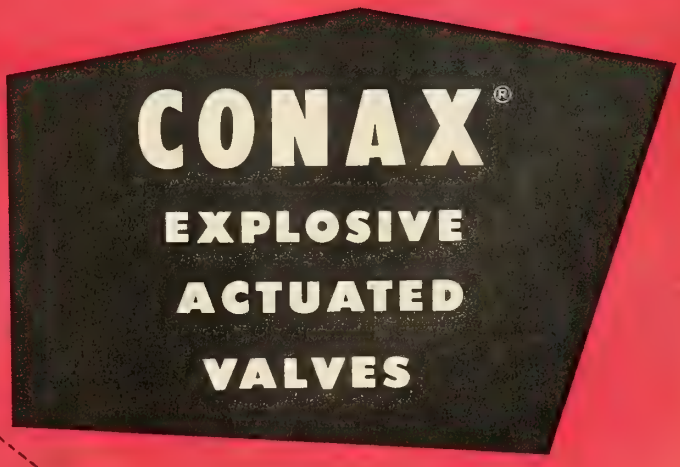
•

Hughes Aircraft Co. has been gradually making over its plant at Tucson, where two versions of the *Falcon* rocket are in production—the radar-guided GAR-ID and the infra-red GAR-2A, both used by the Convair F-102A interceptor. Work on the program, estimated to cost $1 million or more, started about a year ago. It is expected to move rapidly toward completion after the new warehouse, being built by the Tucson Airport Authority for lease to Hughes, is ready for occupancy (in the next couple of weeks or so). This will free main building stores space for manufacturing.

•

We wouldn't vouch for the truth of it, but there's a rumor around that it was President Eisenhower himself who ordered the *Navaho* cancelled when he learned the project's cost was $15 million a month.

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Thermal Gradient from Junction to Mounting Base	1.2°	1.2°	1.2°	1.2° °C/watt
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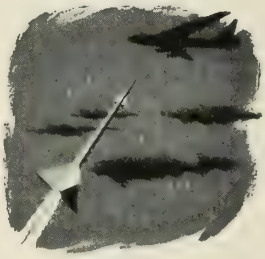
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missile electronics vol. 1, no. 1

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special features

How do we achieve missile electronics reliability? Messrs. G. G. Brown and R. J. Dennis of the Cook Technological Center discuss the problems associated with missile electronics reliability, including the relatively unknown or neglected tools of the trade which can be utilized to advantage in this complex and controversial field (page 172).

Will astrionic instrumentation problems become insurmountable?

The need for more rapid strides in the field of electronic trajectory-measurement systems for missile tests is outlined in an article by American Aviation's Electronics Editor Henry P. Steier. The present basic techniques involved, the systems in current use and possible future systems are considered (page 179).

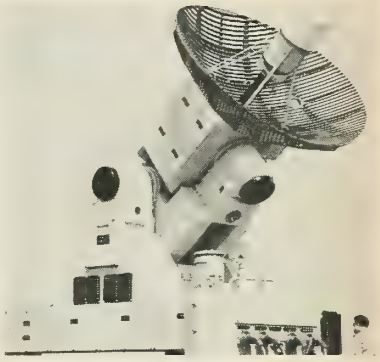
IRBM guidance gyros—air- or liquid-lubricated?

Ballistic missile guidance technology has led to the development of new techniques and requires a continuous and aggressive program of product improvement, especially in the gyroscope field. Assistant Editor Norman L. Baker, presents a brief history of air-bearing gyro development and details the extreme requirements of a gyro test lab (page 183).

Thermocouples or resistance-type measurements for ballistic missiles?

From a mechanical standpoint, thermocouples are the most reliable tools for temperature measurement on ballistic missiles, according to ABMA's Charles T. N. Paludan. Mr. Paludan explains why—and how these measurements are made in the Army's *Redstone* and *Jupiter* missiles (page 185).

cover picture:



Switzerland's achievements in the missile industry can be credited almost exclusively to the Oerlikon Co. of Zurich. The Oerlikon surface-to-air missile (m/r cover) and its associated ground control equipment is a tremendous achievement for a private company. The missile is equipped with a lock-on and track radar. The track radar controls the beam transmitter and the missile launcher. The beam transmitter is equipped with a fine and a coarse beam. The coarse beam locks on the missile after launching and guides it toward the fine beam. The fine beam then directs the missile to the target. Limited by a computer, which controls speed and accelerations of the beams, the transmitter moves at a rate the missile is able to follow.

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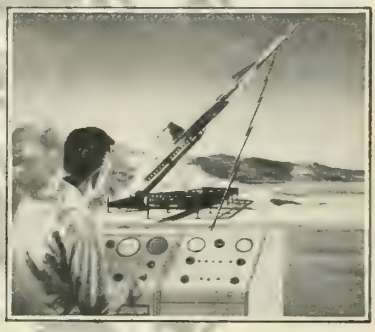
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Lewis Flight Propulsion Laboratory, Triennial Inspection, Cleveland, Ohio, Oct. 7-10.

International Astronautical Federation, Eighth Annual Congress, Barcelona, Spain, Oct. 7-12.

National Noise Abatement Symposium, Sherman Hotel, Chicago, Ill., Oct. 10-11.

Computers in Control Conference, American Institute of Electrical Engineers, Chalfonte-Haddon Hall Hotel, Atlantic City, N. J., Oct. 16-18.

IRE Canadian Convention, Automotive Building, Exhibition Park, Toronto, Canada, Oct. 16-18.

Canadian Aeronautical Institute of the Aeronautical Sciences Meeting, Montreal, Canada, Oct. 21-22.

Aircraft Electrical Equipment, Fourteenth Annual Display, Aircraft Electrical Society, Pan Pacific Auditorium, Los Angeles, Calif., Oct. 24-25.

Computer Applications Symposium, sponsored by Armour Res. Foundation, Morrison Hotel, Chicago, Ill., Oct. 24-25.

Aeronautical and Navigational Electronics, Annual East Coast Conference, Fifth Regiment Armory, Baltimore, Md., Oct. 28-30.

Aviation Electrical Equipment Display, U.S. Grant Hotel, San Diego, Calif., Oct. 30.

IRE, Electron Devices 1957 Meeting, Shoreham Hotel, Washington, D. C., Oct. 30-Nov. 1.

NOVEMBER

Joint Military-Industry Guided Missile Reliability Symposium (limited to those with Secret security clearance), Nov. 5-7.

Aeronautical Communications, Third Annual Symposium, Hotel Utica, Utica, N. Y., Nov. 6-8.

IRE, RETNA, Radio Fall Meeting, King Edward Hotel, Toronto, Canada, Nov. 11-13.

IRE, 3rd Instrumentation Conference and Exhibit, Biltmore Hotel, Atlanta, Ga., Nov. 11-13.

IRE, Mid-America Electronics Convention, Municipal Audit., Kansas City, Nov. 13-14.

National Aviation Trades Assn. Annual Convention; meetings with National Air Taxi Conference, Maintenance Council and Aerial Applicators, Hotel Adolphus, Dallas, Texas, Nov. 13-15.

IRE, New England Radio and Electronics Meeting, Mechanics Hall, Boston, Mass., Nov. 15-16.

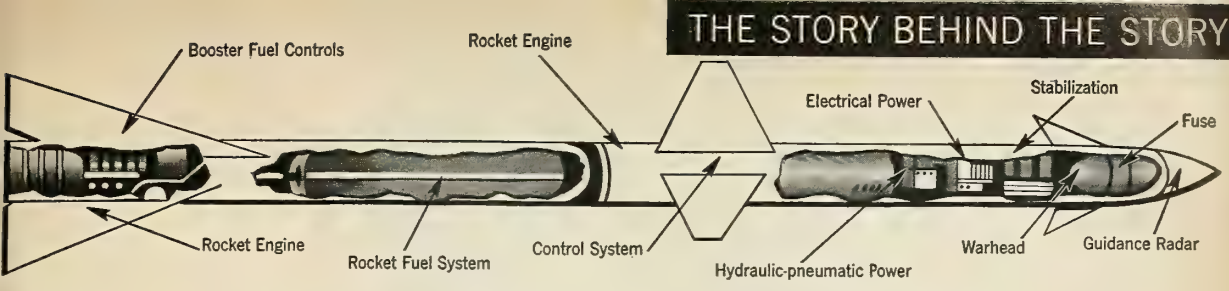
AIEE Magnetism and Magnetic Materials Conference, Sheraton-Park Hotel, Washington, D. C., Nov. 18-21.

Aviation Distributors and Manufacturers Assn., 30th Meeting, Sheraton Cadillac Hotel, Detroit, Mich., Nov. 21-22.

DECEMBER

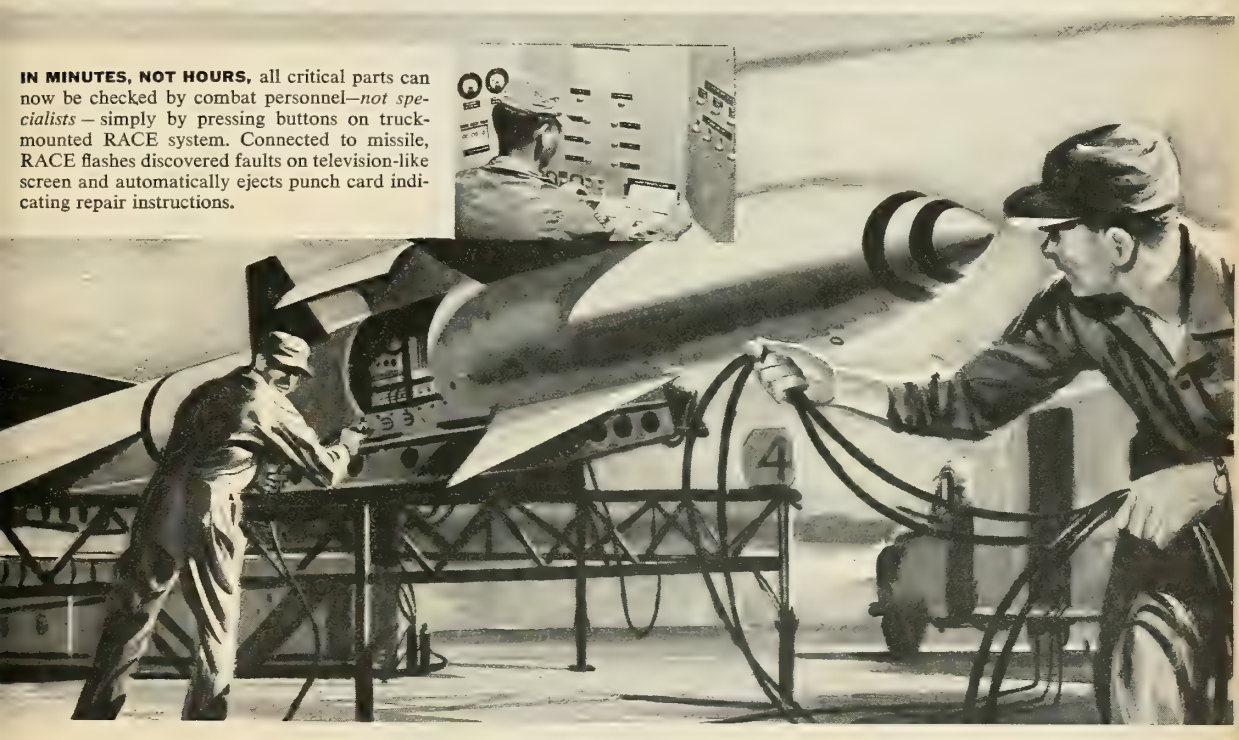
IRE, AIEE, ACM, Eastern Joint Computer Conference, Sheraton-Park Hotel, Washington, D. C., Dec. 8-11.

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THOUSANDS OF "FAULTS" can develop in a guided missile, each capable of causing it to misfire or swerve off-course. Pre-launching check-out takes specialized technicians many hours. Under stress of enemy attack, a small but fatal defect might be missed.

IN MINUTES, NOT HOURS, all critical parts can now be checked by combat personnel—*not specialists* – simply by pressing buttons on truck-mounted RACE system. Connected to missile, RACE flashes discovered faults on television-like screen and automatically ejects punch card indicating repair instructions.



IN FLIGHT, RACE-checked guided missile flashes toward target, performing at the peak capacity engineered into it, with all components functioning to give missile best possible opportunity to reach and destroy objective.



"RACE" TO BOOST MISSILE STRIKING POWER

Electronic System Cuts Launching Time, Ups Dependability

When a rifle bullet misfires you simply fire another. Guided missiles, however, are costly and complex, packed with precision parts in hair-line adjustment. When these "birds" take off, they've got to fly right the first time!

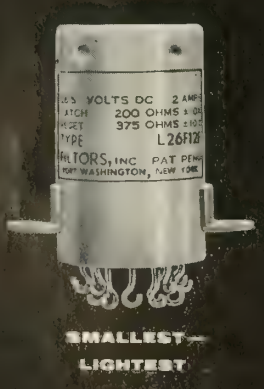
At present, making sure missiles perform properly takes hours, even days, of careful testing by highly trained crews. And under the stress of actual combat, the best-trained crew might neglect an important check-point—and there are thousands of potential trouble-spots in a typical missile.

Sperry's new missile testing system called RACE does the job in only minutes —with little chance for error. RACE (for Rapid Automatic Check-out Equipment) tests all missile components at the launching platform, warns of the tiniest fault, even tells the operator how to fix it. And RACE doesn't make a mistake because it checks itself while it checks the missile. Result is, missiles are ready to launch far quicker and are more likely to perform with full effectiveness.

Designed to test supersonic aircraft as well as missiles, RACE will strengthen our national defense by keeping key weapons fit to fight.

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washington briefs



THE PENTAGON IS INTRIGUED by Maj. David Simons' suggestion that we place "platforms" at altitudes in the neighborhood of 100,000 feet. Simons has commented that the platforms would be permanently fixed installations from which scientists could study cosmic radiation and other phenomena indefinitely. A new need for electronics gear?

NAVAL ORDNANCE LAB IN WASHINGTON has developed an electrochemical device which replaces vacuum tubes or transistors in many electronic systems. Known as solion (ions in solution), the device is sensitive to sound, temperature, pressure and acceleration and is expected to be particularly useful in sensing course errors in inertial-navigation systems.

RELIABILITY, RELIABILITY, RELIABILITY is the echo that follows the word "electronics" in Washington's military circles. Most recent and significant echo came from AMC's commander, Gen. Edwin Rawlings, who warned that contracts would be withheld from industry unless reliability greatly improves. "We must," he said, "accept the fact that where we do not have reliability, we do not have the ability to fight."

DEPARTMENT OF THE NAVY has cancelled the *Triton* ramjet missile program, but will support the program long enough to incorporate the missile's best features, namely its "extremely accurate" guidance system, into other missiles.

LITTON INDUSTRIES WILL BUY Maryland Electronic Manufacturing Corp., located outside Washington, for an undisclosed amount of stock. Maryland Electronic has current sales figures over $3 million, and will become the twelfth Litton plant.

PENTAGON CONTRACTS FOR ELECTRONICS: Two contracts for closed-circuit TV have been awarded to Hallamore Electronics Co. division of the Siegler Corp. The TV systems will be used for monitoring rocket engine tests at Huntsville, Ala. and the Martin Co.'s facility for *Titan* at Denver. Contracts total about $300,000. Cook Electric Co. will design and construct a missile range instrumentation system at Point Mugu, Calif., under a Navy contract valued at $2¼ million. Gilfillan Bros., Inc. has received a $404,745 contract to cover field-engineering services connected with *Corporal* ground guidance equipment.

THE TELEMETRY GAP between the West Indies and Ascension Island has had Pentagon officials worried. It is now being filled by six Army cargo ships (AGSs) converted to carry telemetry gear.

ARMY SIGNAL ENGINEERING LABORATORY nearby has developed a special type solar cell for possible use in satellite power packages. The device has previously been used in research rocket telemetry.

WASHINGTON HAS RECEIVED more evidence of industrial cooperation among NATO members. Compagnie Francaise Thomson-Houston, a French electronics firm, and Decca Radar, Ltd., of Britain, have signed a contract to share equally in providing surveillance radar antennas for NATO air defense.

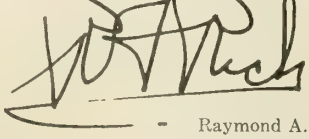
ASTRONAUTICS CIRCLES IN WASHINGTON are pleased at the news that Lockheed has produced laboratory speeds of 100,000 miles per hour. Shock waves are produced in the company's Palo Alto R&D center by a hydromagnetic shock tube using high-voltage discharges which are boosted to tremendous speeds by magnetic fields. The device's shock waves produce temperatures in excess of 100,000°C, and better shock tubes are in the design stage. Much of the data obtained from the devices are expected to be valuable in the study of space travel.

TO MAKE THINGS BETTER FOR AMERICA—

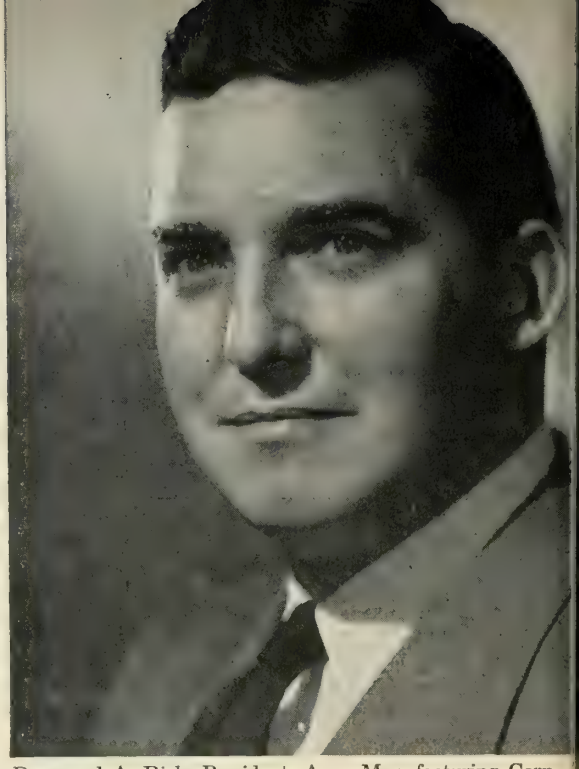
Avco Manufacturing Corporation is a builder of quality products for the commercial economy and high-performance military systems for national defense. Aircraft engines, electronics systems, farm implements, kitchen components and the nose cone for the Air Force Titan intercontinental ballistic missile are being produced by Avco *today*.

The foundation for Avco tomorrow is being laid at our Research and Advanced Development Division. We know that the technology of the future will be built on scientific research being done now. Amazing new materials and new means for creating useful power hold out the promise of great advances in transportation, in agriculture, in consumer products, in nearly every aspect of our future economy. New scientific knowledge and its imaginative application can turn these promises into reality. Work at the Research and Advanced Development Division has already shown what rapid strides can be taken in a short time.

The division is composed of outstanding scientists and engineers who work in an environment that fosters creative investigation. It is the "breakthrough" division of a progressive manufacturing organization. Avco management recognizes the role of the scientist in modern technology. Avco's determination to make things better for America places the resources of a large, diversified, aggressive company firmly behind the Research and Advanced Development Division.



– Raymond A. Rich
President, Avco Manufacturing Corporation



Raymond A. Rich, President, Avco Manufacturing Corp.



Pictured above is our new Research and Development Center now und construction in Wilmington, Massachusetts. Scheduled for completion early 1958, this ultramodern laboratory will house the scientific and te nical staff of the Avco Research and Advanced Development Divisi

Avco's new research division now offers unusual and exciting career opportunities for exceptionally qualified and forward-looking scientists and engineers in such fields as:

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Physical Chemistry • Physics • Thermodynamics

Engineering:
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Write to Dr. R. W. Johnston, Scientific and Technical Relations, Avco Research and Advanced Development Division, 20 South Union Street, Lawrence, Massachusetts.

Avco
Research and Advanced Development

3000-Mile Anti-ICBM Radar Claimed

Line-of-Sight Radar Being Developed in Conjunction with Anti-Missile Missile

A radar capable of detecting intercontinental ballistic missiles (ICBMs) 3000 miles away is under development by the U.S. Though still in the development stage, Gen. Thomas D. White, AF Chief of Staff, announced that the radar will be available for operational use very soon.

The radar would warn civilian and military centers shortly after the enemy ICBMs were launched. Thus, appropriate defensive action could be taken almost immediately. Gen. White predicted that fear of such action would probably deter aggression, and marks an important victory in the military era of electronics.

It would also be an important "breakthrough" in the state of the art. No details as to the nature of the "breakthrough" were disclosed by the general or Air Force spokesmen, since the project is still highly shrouded in secrecy. However, it is logical to assume that the "breakthrough" occurred in the field of line-of-sight applications. Informed sources conjectured that the achievement was the one referred to in a recent Columbia University news conference. At the conference, according to one of the sources, the recent "breakthrough" was hailed as "probably the greatest single advance in radar" since 1939.

Development of the 3000-mile radar nevertheless raises many implications for tactical and strategic operations.

Prime contractors in the development of the radar are the Lincoln Laboratory, Radio Corporation of America, Sylvania Products, and General Electric. No information is available as to who contributed what to the radar.

Operating presumably on the line-of-sight principle, the new radar will be able to see only objects in or above a straight line tangent to the earth. Thus, though it will be able to detect ICBMs at long ranges (because of their relatively high, loping trajectory in the initial phase), it will be unable to detect short-range missiles and low-flying aircraft.

When employed against ICBMs, the radar will enable computers to determine not only trajectory and speed but also size and shape. As a result, it would be possible to determine the specific target in advance, the type of missile used and the location of the launcher. The amount of warning time that would be given for the average missile launched from the Soviet Union would range, it has been estimated by authorities, from 10 to 15 minutes.

Given that much time and knowledge of the trajectory and speed, the most immediate objective of course, would be destruction of the missile. This would imply the availability of an effective anti-missile missile. However, as far as is publicly known today, no such missile exists, although Gen. White in his announcement explicitly stated that one was being developed with utmost "urgency." He was probably referring to the Army *Nike-Zeus* and the more recent Air Force *Wizard* project.

Lacking an effective anti-missile missile, there is a possibility that the military might accept full-effort retaliation as the only recourse. Thus the new radar might signal a total offense.

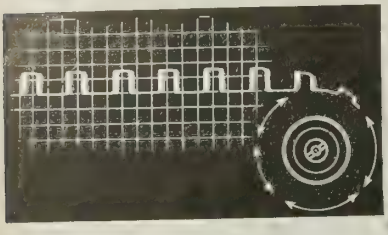
A missile battle, or even a missile war, might be fought without sufficient time to inform political leaders. Given an equally effective ICBM-detection radar in the hands of the enemy and effective anti-missiles in the hands of both enemy and friendly forces, both sides could conceivably detect and destroy each other's missiles in a matter of seconds or minutes. It would not particularly matter which side fired first. And, of course, if the action took place in the Arctic wastelands, it is quite possible that the civilian population might not know about it.

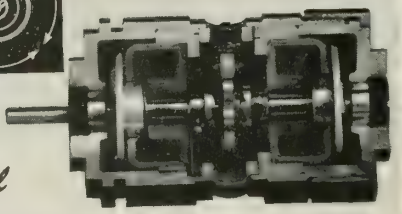
Telemetry Use For Manned Space Vehicle

Whenever electronic engineers gather to discuss their profession, the question inevitably arises about the future of telemetry when manned space ships come into use. In view of the continuing and increasing interest in the question, we feel it would be helpful to quote from the statement of Mr. Martin V. Kiebert, Jr., director of electronic development at Miami Shipbuilding Corp. Writing in SIGNAL for the eleventh convention of the Armed Forces Communications and Electronics Association, Mr. Kiebert said:

> Manned space craft will probably employ telemetering and remote-control functions (as aided by both carried and ground-based computer facilities) for the following functions:
>
> 1) Telemetry can be used to fix a landing position provided previous facilities have been so established.
> 2) Ground-based radar and computers will be available for landing on the earth; however, the lack of these facilities on the celestial bodies now makes it appear essential that the space craft carry its own radar and high - frequency - response computer system.
> 3) Telemetering may be required on the earth as an advisory means as to when and where landings may be

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OTHER MODELS AVAILABLE WITH VARIATIONS FROM THE ABOVE SM-300-1 SPECIFICATIONS.

The two rotary solenoids contained in each motor produce the incremental motion of the output shaft in either direction. Energizing either of these solenoids produces a combination of linear and rotational motion which moves a ratchet gear axially into engagement with its mating ratchet gear and thus imparts a constant amount of rotation to the output shaft. The detent roller assembly insures constant, reproducible angular shaft rotation increments in either direction and maintains the output-shaft position while the motor is at rest with the power off.

Stepper Motors are adaptable to routine jobs such as driving mechanical counters. They also find excellent use in positioning devices that will set up a controlling voltage and/or a phase shift such as potentiometers and autosyns. They are widely used as a positioner for guided missiles to adjust heading, fuel flow, altitude, and circuit sampling for telemetering purposes. In one adaptation as a heading controller, two Stepper Motors are used to position a differential autosyn in steps of either vernier degree or coarse degrees per input pulse, bi-directionally, through a suitable gear train.

Write for more details—available upon request.

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made, and re-orientation of inertial references to the earth's coordinates.

4) The role of telemetering in the landing of extra-atmosphere space craft on celestial bodies. It appears that telemetry will serve as an extremely important element in the landing of space craft on previously unexplored celestial bodies as indicated. Knowledge of both the physical and chemical environment on a proposed celestial body will be essential for survival of both the craft and the crew.

Radioactive Cobalt Aids Missile Recovery

The Era Engineering Corp., Santa Monica, Calif., has announced a radioactive recovery technique to insure post-flight recovery of missile and rocket test vehicles.

Originated by Harold Hutchinson, company vice president and radiation expert, the simple and relatively inexpensive technique has been used successfully on Aerophysics Development Corp.'s Hypersonic Test Vehicle.

In a typical operation, the one-to-two-ounce radioactive source, contained in a one-inch long, 3/8-inch O. D. Allen screw, is removed from its lead shield ten minutes before launching, and placed in the test vehicle by means of a six-foot aluminum rod fitted with a magnetized Allen wrench at one end.

Although the impact point of a vehicle is seldom observed visually or by radar, it is usually known to be within a square of approximately ten miles to a side. This area is searched by flying parallel grid lines about 3000 feet apart in light aircraft or helicopters equipped with scintillometers until the vehicle's radioactive source is detected.

It normally requires three hours to search an area of this size using such a flight pattern, but the results of 40 tests using the radioactive technique produced an average location time of just 30 minutes.

Once the site is located and marked with flares a specially trained recovery crew transports the trailer-mounted lead shield to the impact point, removes the radioactive source with the aluminum rod and places it in the lead shield. The source may be removed from its shield and placed in the test vehicle, or vice versa, in from 30 seconds to one minute.

Under normal conditions, the crew receives negligible and often unmeasurable amounts of radiation. Even in cases where the vehicle broke up in flight, the dosage was not in excess of the daily allowable maximum.

Radioactive intensity is not affected by high shocks or G forces encountered in flight nor will the source itself affect

electronic equipment and for short periods has no affect on ordinary film.

The original radioactive source consisted of two Curies of Cobalt 60 with a half life of 5.2 years and an effective lifetime of 20 years. A new source has been recently introduced—four curies of Antimony 124 with a half life of 60 days and an effective lifetime of eight months. The latter was introduced to reduce the hazard if a vehicle impacted in a stable condition, buried itself and was never found.

The company points out that there are many other uses of this recovery technique such as camera pods, instrument packages, propulsion units and material specimens ejected from test vehicles during upper atmosphere studies.

Bomb casings that "dig in" after drop tests may be located by two modifications to the technique: the attenuation effect of the ground can be accommodated by using a more intense source and an isotope which emits high energy gamma rays can be used.

Era can also supply millicurie (1/1000 curie) sources for aircraft flight testing which may be used to locate valuable individual components in the event of pilot bailout or destruction of the aircraft. These small sources require little or no shielding to protect aircraft operating personnel.

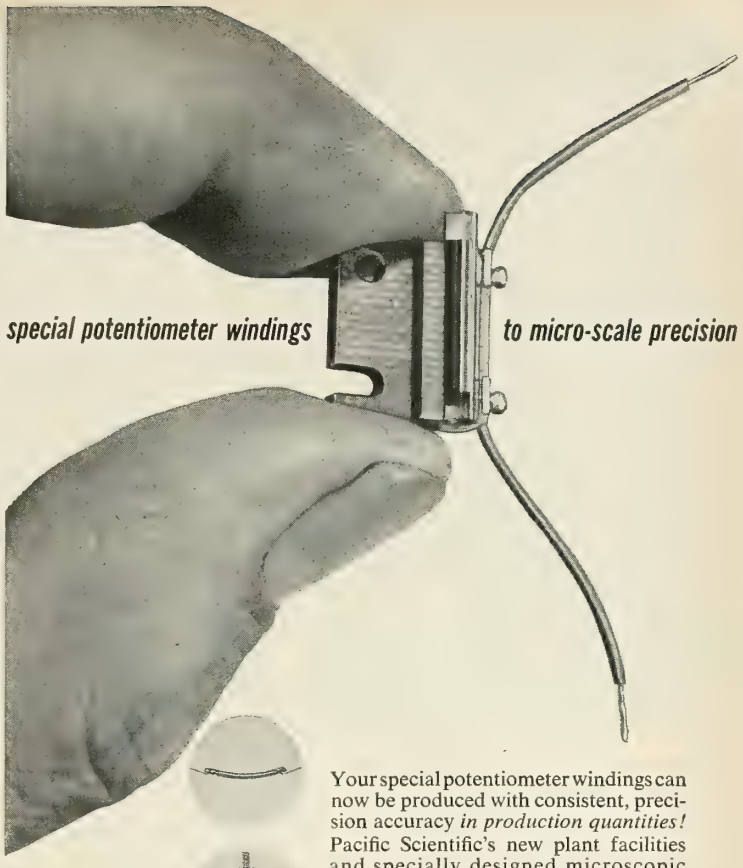
The recovery system may be supplied either as a contract service, in which Era provides trained personnel and equipment, including the design and fabrication of source capsules to fit the user's needs, the procurement and storage of the source pellets and the installation and subsequent search and location.

If a user wishes to purchase the equipment and conduct his own operations, Era will furnish all necessary equipment, provide initial training to fit the user's applications, arrange for the supervisor's training course and assist in the application for Atomic Energy Commission authorization.

Sperry's Super Radar To Guide *Talos* SAM

Sperry Gyroscope Co. has developed a "super radar" which the Navy plans to use in the *Talos* surface-to-air missile. The radar unit is said to include many automatic functions and the ability to pick up targets many miles beyond the horizon.

Included in a long-secret class of super-radars developed for the Navy, the SPG-49 *Talos* uses an antenna that resembles a gigantic searchlight. The system is reported to be providing "exceptionally high performance for tenacious, stable guidance of supersonic missiles, whether fired singly or in



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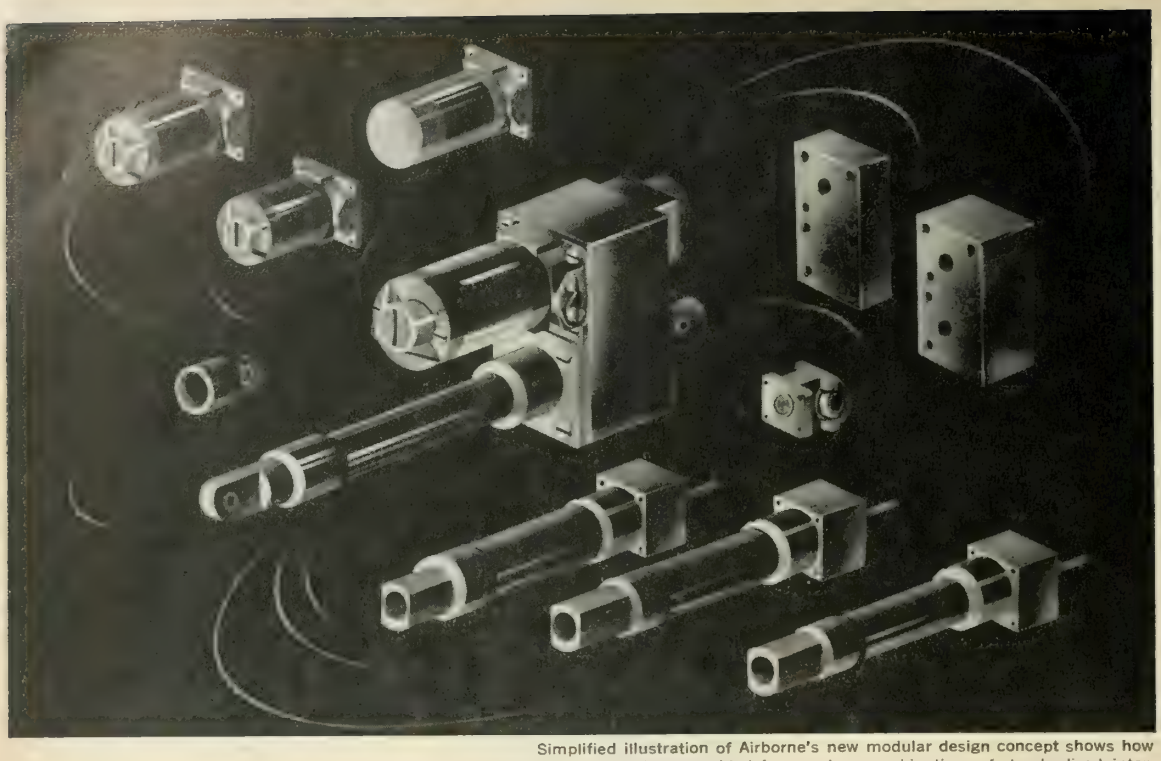
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Simplified illustration of Airborne's new modular design concept shows how actuator can be assembled from various combinations of standardized, interchangeable parts. Components actually available appear in the diagram below.

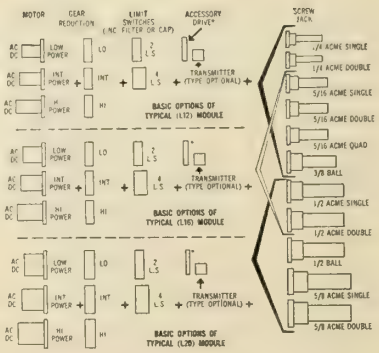
New Airborne modular actuators give you greater design freedom, help eliminate specials

Airborne's new modular concept of linear actuator design is based on a system of standardized components. These components—motors, switches, jacks—are grouped in three broad operating capacity classifications: L12—up to 350 lb.; L16—up to 2500 lb.; and L20—up to 3500 lb. All components within each classification are interchangeable.

As a result, you are no longer limited to a line of, say, a dozen standard actuators whose design is relatively fixed. Instead, you can now select any one of several hundred possible combinations from over 40 standard Airborne actuator components. In 90% of cases, this will give you a linear actuator meeting your capacity and configuration requirements exactly. Thus you have greater design freedom without becoming involved in the extra costs and delays associated with specials.

In addition, while redesigning under the modular system, we have reduced the bulk and increased the capacity of many Airborne actuator components. You get more power in a smaller package, saving valuable weight and airframe space.

Write today for further information on Airborne's new modular actuator line.



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NEW MODULAR ACTUATOR CATALOG 57A

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salvos at individual or multiple targets."

Development of the system was the responsibility of Sperry's surface armament division and the company says that production contracts for the SPG-49 system currently total more than $47 million.

Autonetics Components Tested at 90,000 Feet

Autonetics, a division of North American Aviation, Inc., has successfully carried out functional and environmental testing of components at an altitude of 90,000 feet. The tests, conducted on electromechanical components for guidance and control systems, were performed in a metal-framed gondola carried aloft by a General Mills balloon from New Brighton, Minn.

The gondola was designed by Autonetics engineers, while General Mills provided the balloon and handled launching operations.

Two Advanced Transistors Developed by RCA

A germanium p-n-p alloy-type transistor embodying the "drift" principle and a junction transistor of the germanium p-n-p type have been developed by RCA's semiconductor division.

The compact design of the former opens new applications in military and commercial equipment where space is limited. It operates at frequencies extending from the standard AM band well up into the short-wave bands. It may also be used as a mixer-oscillator and has a high input circuit efficiency, excellent operating stability, good automatic-gain-control capabilities and a good signal-to-noise ratio.

The junction transistor is designed for use in switching circuits of compact, medium-speed military and industrial electronic computers. It has characteristics permitting the design of electronic computers having exceptional stability over wide temperature ranges.

Transistorized System to Measure Liquid Levels

A transistorized electronic system for measuring the level of liquid in any of 100 remotely located storage tanks, with accuracy of performance, reliability and self-checking features has been developed by Texas Instruments Incorporated.

Called the DATA-GAGE, the system was designed and developed to control liquid materials stored in large tanks.

Du Mont Establishes Forward Scatter Link

The successful operation of a complete "forward scatter" communications link in frequencies above 2000 megacycles has been established by Du Mont. According to the company, the path length of the new link is 124 miles, and transmission and reception are at 2180 megacycles. The transmitter is located at Cedar Grove, N. J., the receiver at Somers, Conn., near the Massachusetts state line.

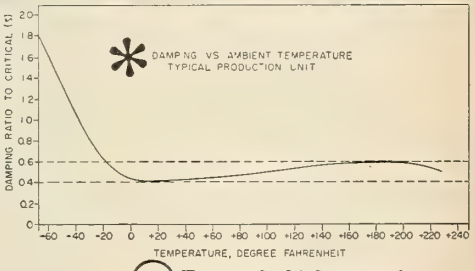
The equipment has been developed and designed for high reliability, ease of maintenance and operation. The design and systems concept allows application of the equipment to both line of sight and scatter communication multichannel links.

The transmitter dish of the system has an 18-foot diameter and is mounted on a 24-foot tower. It is connected by wave guides to a one-kilowatt transmitter utilizing an air-cooled Eimac klystron tube. The transmitter is capable of 72 voice channels with a band-width of 2.5mc.

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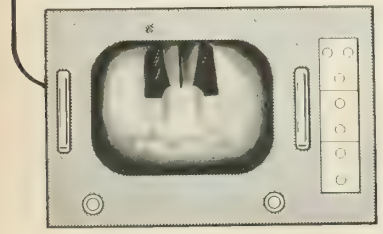
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A unique feature of the transmitter is a magnetic-amplifier-regulated power supply for the klystron, which requires no tubes.

Reception at Somers utilizes two 10-foot dishes on 25-foot towers. The specially designed, highly sensitive 52-tube dual diversity receiver operates reliably on a signal strength of eight microvolts.

Manufacturers Favor Two Annual Trade Shows

The average electronics manufacturer received almost a 50 per cent increase in the number of requests to exhibit his products at trade shows during 1956, according to a survey just made by the Electronic Industries Association.

Cost per show increased from $1712 in 1955 to $1916 in 1956 for the average manufacturer. For parts, tube and semiconductor manufacturers, however, the cost was below the industry average for both years.

Regarding industry attitude toward the increasing number of shows, replies indicated only 13 per cent favor more than four shows a year, and more members favor two shows per year than any other number.

Magnetohydrodynamics: Latest Combined Science

The recent outstanding research work of 11 top U.S. and British physicists and astronomers in the new field of magnetohydrodynamics—combining the sciences of fluid flow and electromagnets—has now been compiled in a volume edited by Dr. Rolf K. M. Landshoff, consulting scientist of the Lockheed Missile Systems Division.

The book, MAGNETOHYDRODYNAMICS, just published by Stanford University Press, grew out of the talks and discussions at a year-end Lockheed-sponsored symposium attended by 200 leading scientists at the company's missile division laboratories in Palo Alto, Calif.

Magnetohydrodynamics, a new branch of physical science, is a study of how magnetic fields influence and are influenced by ionized gases which are brought about at extremely high temperatures.

The foreword to the new book is by Dr. Louis N. Ridenour, assistant general manager for research and development, Lockheed Missile Systems Division. He also presented the welcoming address at the symposium.



This Army Signal Corps DIANA moon radar has been used recently to bounce signals off the moon in efforts to develop a technique for the testing of VANGUARD and other satellite tracking stations. The unit may be used in calibration of MARK II stations.

astrionics



By Henry P. Steier

THERE IS SPECULATION THAT SUPER-RADARS located in the Near East might be spotting flights of Russian IRBMs and ICBMs! Be that as it may, there *has* been a flurry of news on new radar techniques tried by the military. One of these was use of the moon as a reflector for 151-megacycle signals from Army Signal Corp's giant DIANA radar to test satellite tracking stations. Then came Columbia University's announcement of Omnirange Digital Radar for long-range missile detection. ORDIR is said to have a 2500-mile capability for measuring range and velocity with great accuracy. Another report told of Naval Research Laboratory's moon radar antenna made by scooping out earth to form a parabolic reflector over 200 feet in diameter and lining the hole with iron mesh. Navy says it has used the moon as relay station for voice signals.

AIR FORCE IS TRYING ITS OWN APPROACH to calibration of satellite tracking antennas. Cambridge Research Center, ARDC has designed a receiver with time-integrating circuits that allow very low levels of satellite signals to be detected. This in turn should add accuracy to angle information at the instant of satellite transit. It might also allow the antenna to be calibrated by means of radio stars and also be suitable for navigation by radio astronomy.

MOST SENSITIVE SHORT WAVE RECEIVER and farthest reaching transmitter is the new 250-foot diameter steerable radio telescope of the University of Manchester in Great Britain. Beam angle of the telescope will be about one degree at a wavelength of one meter and power gain will be over 16,000. At the wavelength of the spectral line at 21 centimeters, beam angle will be only a few minutes of arc. New detailed maps of radio sources in the sky plotted with the new instrument will add significant new data for use in radio celestial navigation as well as aid studies of the moon, radio echos from meteors and solar-terrestrial relationships.

DURING HIS RECENT TALK AT WESCON on the AF ballistic missile program, Maj. Gen. Bernard A. Schriever put the accent on accelerometer technology to illustrate fields where enterprising electronics firms can make their mark. He said, "Since the interest in mouse traps has begun to wane, the world would probably beat a path to the door of someone who built a really outstanding accelerometer. Most particularly if he could do it for a reasonable price." This column previously noted price of accelerometers as $5000-$10,000 per pound (m/r July 1957).

WORK ON MOVEMENT OF IONS IN SOLUTION UNDERTAKEN BY U.S. Navy researchers may pave the way to devices that replace vacuum tubes and transistors when high sensitivity and low power consumption are vital. The new electrochemical control devices generate current by movement of ions between electrodes in an iodine solution. Current is varied or sustained by stimulation caused by temperature, pressure, light, sound or acceleration. A promising use would be as an integrator in inertial systems. Several hundred pounds of electronics might be replaced by an electrochemical integrator weighing a few ounces.

ARMY IS PLACING MOUNTING EMPHASIS ON ITS RECONNAISSANCE needs for nuclear-age war. Missiles and drones, heavily equipped with new electronic surveillance gear, will probably appear in increasing numbers to form a whole new family of vehicles suiting new Army concepts. These are controllability over greater depth and breadth of area, utilization by higher echelons, increased transportability of input and output systems. Army needs for the new airborne vehicles ought to kick off many electronics-airframe company tie-ins during 1958.

electronics reliability

A sticky art becomes a sensible science as first tools of the trade are developed

By G. G. Brown and R. J. Dennis

Inland Testing Laboratories
Cook Technological Center

THE RELIABILITY PROBLEM has been stated and restated many times. Most engineers concerned with missiles or military electronics have devoted some time to pondering a solution. However, one encouraging sign in the swirl of component reliability confusion is that engineers today are aware that a problem exists, and the terms and phrases of reliability and statistics, failure rate, mean-time-to-failure, confidence limits, etc., are a necessary part of their vernacular. This in itself is progress.

Even though familiarity of the concepts exists, there are still shortcomings. Important aspects of the art are relatively unknown or are being neglected. The tools of the trade are at hand, but who should be using them and how are they to be used? The true value of any tool is in its application and utilization.

To achieve the extreme reliability of complex electronic systems under obtuse environmental conditions, comprehensive component criteria must be established and put to day-to-day use. These criteria (Table I) are the basic tools of the reliability art. It then remains to exemplify how and by whom they should be utilized.

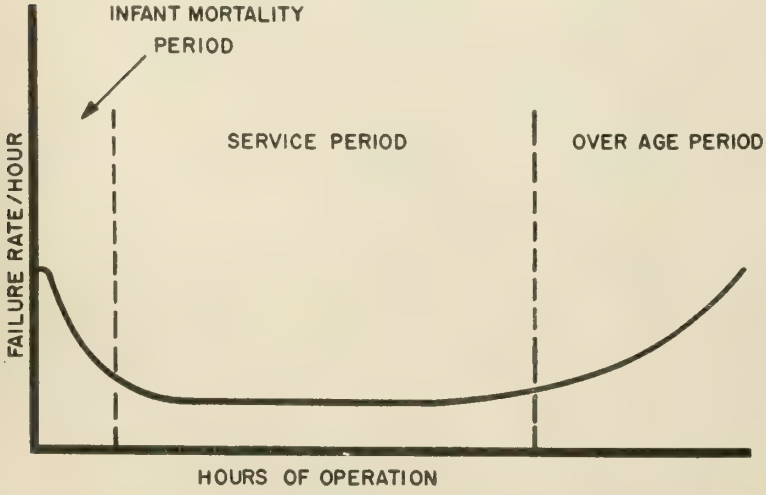


Figure 1. Component failure rate vs. operating time.

Failure Rate Curves

An example of the familiar three-part failure rate curve showing early, random and wearout failures is depicted in Fig. 1. Failure rate per hour is the ordinate and time the abscissa, with the three intervals being defined as the infant mortality screening period, service period and over-age period.

For simplicity, only catastrophic failures are shown. A more useful presentation would include a family of curves as shown in Fig. 2. The catastrophic failure curve is repeated and others added, showing cumulative catastrophic and out-of-tolerance failures for progressively decreasing tolerance limits. These curves take into account the fact that malfunction may occur under conditions that are less stringent than absolute component destruction.

Environmental stress as well as primary circuit stress has a considerable effect on failure rate curves. Failure rate as a function of circuit stress can be combined with the failure rate as a function of environmental stress. This serves to define a surface in a three-dimensional system. An example of such a three-dimensional presentation is illustrated in Fig. 3 where temperature has been added as a third parameter. The infant mortality period is shortened, the useful service period is reduced and failure rate in general becomes progressively higher as temperature increases to extremes.

Parameter Drift Curves

There are many ways by which

component drift may be graphically portrayed. To name a few: the change from the nominal or initial value could be plotted vs. time, circuit stress or environmental stress; the number of components drifting beyond given tolerance limits could be plotted against time; or the percentage of a total component population vs. per cent change in the measured parameter at a particular time.

Fig. 4 illustrates the per cent change in the resistance of two different nominal values of composition resistors during their operational life. A plus or minus 10 per cent design tolerance has been superimposed on the graph and shows that the resistance of the highest nominal value has drifted above this design limit after 8000 hours of operating time. The curves also indicate that the resistance change is relatively independent of nominal value.

The resistors as received were all within plus or minus 5 per cent of their nominal values. Consequently, they could have been ordered as a nominal value at least five per cent lower and still have been within the design specification limits. This would have permitted considerably longer equipment operation before the components drifted above the upper specification limit as shown by curves R_{2a} and R_{2b}.

Fig. 5 incorporates the results of parameter drift measurements over a period of 10,000 hours and compares the findings for two test groups of components, each of which is subjected to a different condition of electrical loading (other environmental conditions being the same). The two degrees of electrical loading, one group at 100 per cent of rated and the other at 50 per cent, illustrate the effect of derating on component life.

An initial distribution, derived from measurements made on individual components as received from the manufacturer and prior to environmental exposure, is shown in the first position on the left in the series of histograms in Fig. 5. This distribution shows the per cent deviation of the measured parameter from the nominal component value.

Succeeding histograms, shown for 2000 hour intervals, depict subsequent changes in the component parameter based on the actual initial value of each component. A mean value is computed for each of the aforementioned frequency distributions. Its position is indicated by the point of intersection between the interconnecting dashed line and the ordinate scale for individual histograms.

The path described by the dashed line progressively defines the mean change in parameter as it varies with the period of component exposure to a specific environment. This method of data presentation for parameter measurements enables the user to exercise his preference in considering the performance of the components as individual units or as a group.

Comparison of the two series of curves exemplifies the advantages to be gained by 50 per cent derating of this particular type of component. As an example, consider a circuit in which a change greater than 10 per cent in the component parameter is critical and would cause malfunction of the equipment. At 6000 hours, eight per cent of the units operating at 100 per cent of rated capacity could be expected to be outside this limit (shaded area), whereas all of the derated components are satisfactory.

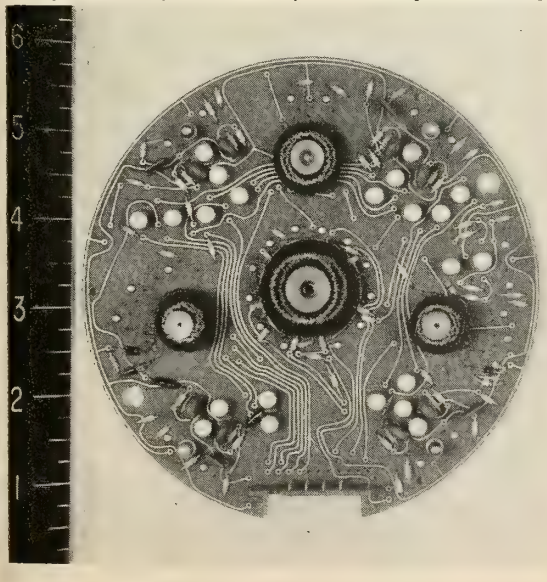
A critical change in the derated units occurred between 8000 and 10,000 hours of operation when two per cent of the units experienced an 11 per cent change in parameter. Thus, it is readily discernible that a gain in operational life of at least 2000 hours has been realized by derating the components.

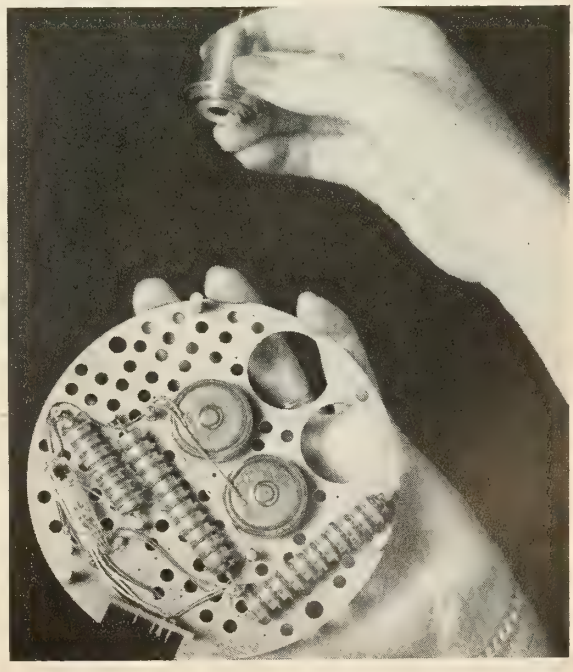
Failure Analysis Data

One of the most valuable items at our disposal is the component which fails under known conditions. This is our third basic tool toward the attainment of improved reliability. A study of the basic molecular properties of failing components can be used to determine the mechanics of failure.

Initial studies of component failure indicate that it is possible to get information on the physical structure of a component that could then be applied to 100 per cent incoming inspection of this type of unit. Based on this knowledge, X-ray, electron microscope, spectrographic, or X-ray defraction tech-

Examples of some of the circuitry and electronic components with which missile telemetry and guidance engineers are concerned: Below shows a multi-channel telemetry wafer from the instrument package that will be placed in an orbit in the VANGUARD satellite. To the right is the "eye" and circuitry for measuring ultra-violet light.





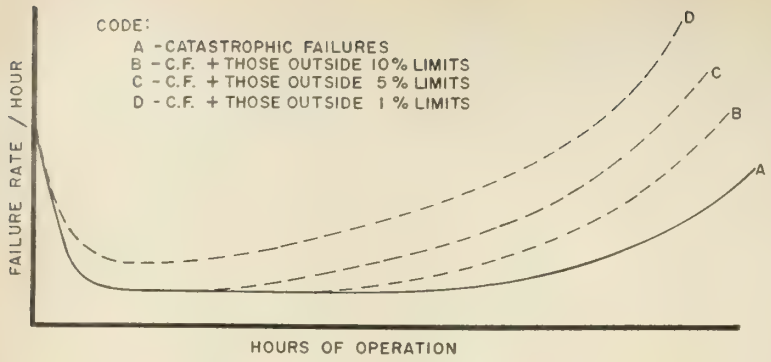


Figure 2. Component failure rate per hour.

niques could be used to screen components which would be potential failures from the total production lot.

Component Screening

Screening of component parts may be done on either a partial or 100 per cent sampling basis. An example of partial sampling is the application of destructive accelerated test techniques to a portion of incoming components. Of much greater value, however, are nondestructive techniques that may be applied to all components that are to be used in the equipment.

Two good examples of 100 per cent sampling are physical inspection and marginal testing techniques. If it is to be used to improve reliability, physical inspection presupposes knowledge of a property or properties of a particular component type which would serve as an indicator of potential failure. For this reason, it cannot be universally applied to all components until extensive studies of the failure mechanism of each individual type have been made. On the other hand, marginal testing techniques are currently used in the computer field for almost all electronic components and have met with great success in this area.

Marginal testing can be defined as operation under more severe conditions than are normally present, but that are still within the individual component's rating. An example of such a test would be operation of diodes with −50 volts reverse voltage applied and 20 milliamperes forward current, where normal operation is at −2 volts reverse voltage and 1 milliampere forward current. The −50 volts and 20 milliamperes are within the diode ratings, so the components should not be overstressed.

What benefits are to be gained by the use of component screening in actual practice? The information presented in Table II demonstrates how component reliability could be substantially improved by screening 90 per cent of the potential failures that would otherwise have been used in the equipment. It is based on the exponential failure law:

$$P_s = e^{-N\lambda T}$$

where

P_s = Probability of survival
λ = Failure rate per unit of time
N = Number of components of a specific style
T = Desired period of failure-free operation

This law is applicable to equipment which has a constant failure rate and where the probability of survival, computed during the life span of the device, remains unchanged. Under these conditions, the probability of survival (P_s) will vary exponentially when evaluated for different periods of failure-free operation (T).

Table I

Tools of the Trade

1) Failure Rate Curves or Reliability Indices
2) Characteristic or Parameter Drift Curves
3) Failure Analysis Data
4) Component Screening Techniques
5) Trade-off or Compensation Techniques

The benefits of screening can best be demonstrated by considering a piece of electronic equipment composed of five different types of components, each type having one of the failure rates that are shown in Table II. The probability of survival for this equipment would then be equal to the product of the probabilities of survival for the several different styles of components which make up the unit.

$$P_s \text{ (group)} = P_{s1} \times P_{s2} \times P_{s3} \times \cdots\cdots \times P_{sn}$$

From this relationship, the calculated probability of the equipment surviving for 10 hours, if initial component screening was not employed, would be 0.51, and approximately 50 per cent of the units could be expected to fail during any 10-hour operating period. On the other hand, if preproduction component part screening was conducted, the probability of equipment survival would be 0.935, thus obtaining an increase of more than 40 per cent in survival probability by utilizing screening techniques.

Trade-Off Techniques

The word *trade-off* usually brings to mind the idea that something irreplaceable is lost, and therefore some doubt is cast on the benefits which can be derived by utilizing this technique. But the gain may outweigh the loss. A good example is the use of negative feedback in amplifier design. It is true that negative feedback has one basic disadvantage—it reduces the over-all voltage gain, but its many advantages such as improved frequency response, increased signal-to-noise ratio, improved stability and reduced distortion more than compensate for this loss.

Some examples of trade-off or compensation techniques which may be applied to reliability are: (1) Derating or load compensation, where the component is operated at a reduced load condition to increase service life; (2) environmental compensation, where

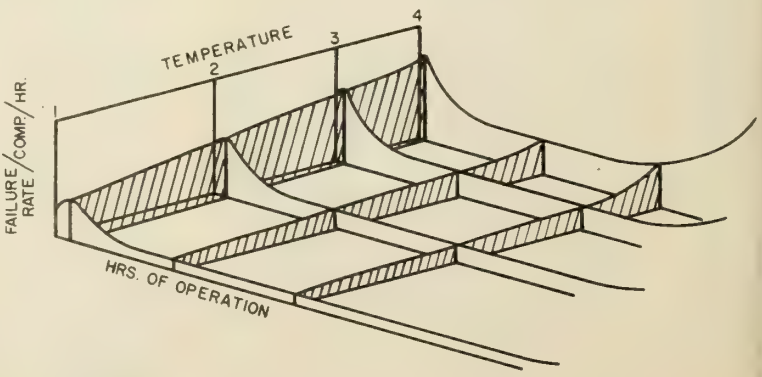


Figure 3. Effect on component failure rate by increase in temperature.

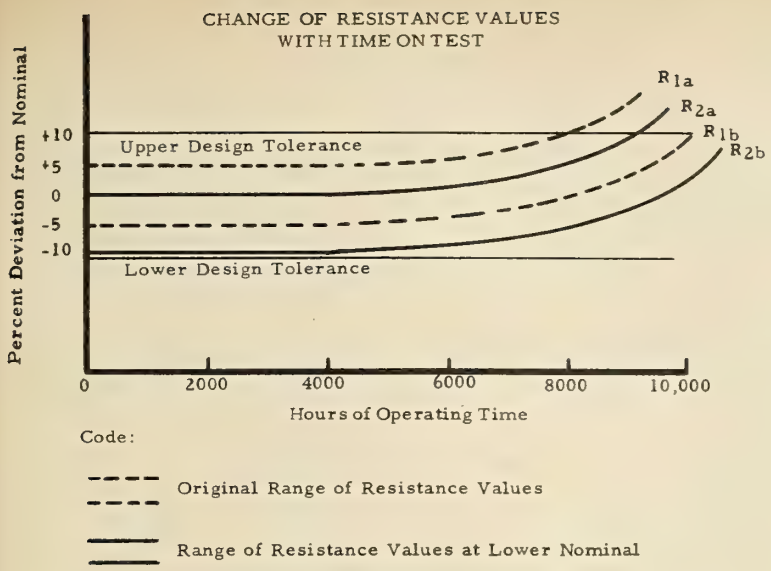


Figure 4. Change of resistance values with time on test.

weight and size are sacrificed to provide insulation or cooling to reduce the components' operating temperature; (3) redundancy, where substitute or parallel parts come into use upon failure of the primary circuits; and (4) compensation for drift characteristics in which components are chosen with opposite drift characteristics. Judicious use of these techniques can greatly improve the over-all system reliability.

After exploring the use of tools and techniques, consider again the question raised at the beginning: "Who should be using them and how are they to be used?" The obvious answer is the design engineers, component application engineers, and quality control engineers. However, the techniques which have been presented can also be utilized by purchasing department personnel, test engineers and field service engineers. Each of these individuals or groups can gain invaluable information from the reliability data and curves that have been brought up, and thus contribute to an increase in equipment reliability.

Use by Design Engineers

During the equipment design stage, many decisions must be made by the design engineer that would be substantiated by component capability data. Component reliability indices or failure rate curves provide information in the initial design stages to establish the feasibility of the preliminary design; environmental stress failure rate curves pinpoint the critical areas where trade-off techniques would be effective; and component derating and characteristic drift curves provide guidance for the application of these techniques. For example, if the circuit designer has knowledge of parameter drift with time

Table II

Improvement of Reliability by Screening

Per Cent Failure Rate/1000 Hours	Probability of Component Group Survival for 10 Hours*	
	No Screening	With Screening
0.1	0.99	0.999
0.5	0.95	0.995
1.0	0.90	0.99
2.0	0.82	0.98

*Figures based on a quantity of 1000 components and 90% screening of potential failures.

for component types under various conditions, it is possible to select two or more components with compensating drift. An example of such an application to the design of an RC timing circuit is shown in Fig. 6.

A composition resistor used in the circuit increases in value with operating time. A capacitor could therefore be chosen which had a negative drift characteristic, thereby providing little or no change in the circuit-time constant during the operational life.

Parts-Application Engineers

Parts-application engineers are responsible for determining a component's suitability for a particular application and serve in a consultant capacity to the design engineers. They should have at their disposal component failure rate, derating, and characteristic drift information. Many uses will not require the most reliable components available, and these engineers select the most economical components for a particular application based on failure rate data.

Characteristic drift curves will assure optimum selection of nominal values; if a component characteristic drifts in an upward direction during its operational life, as previously illustrated in Fig. 4, then one would want to select a nominal value somewhat

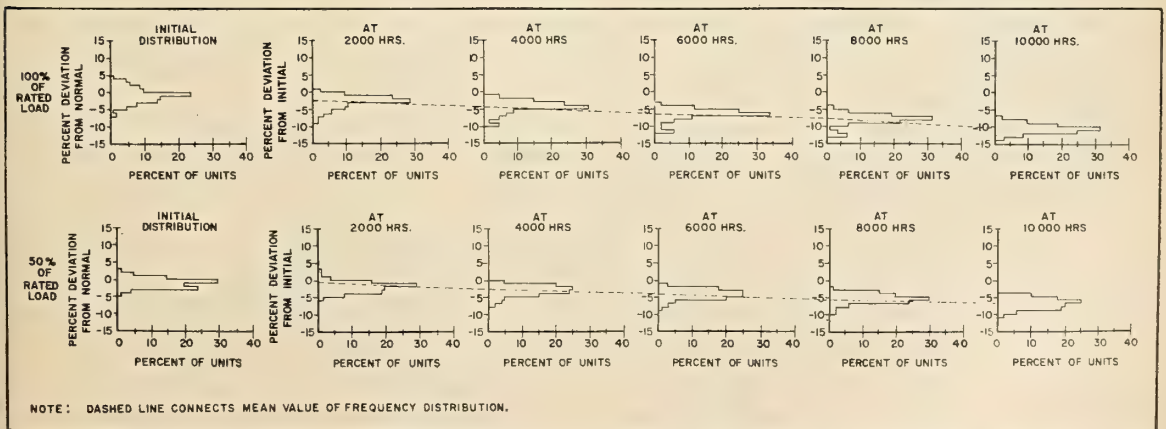
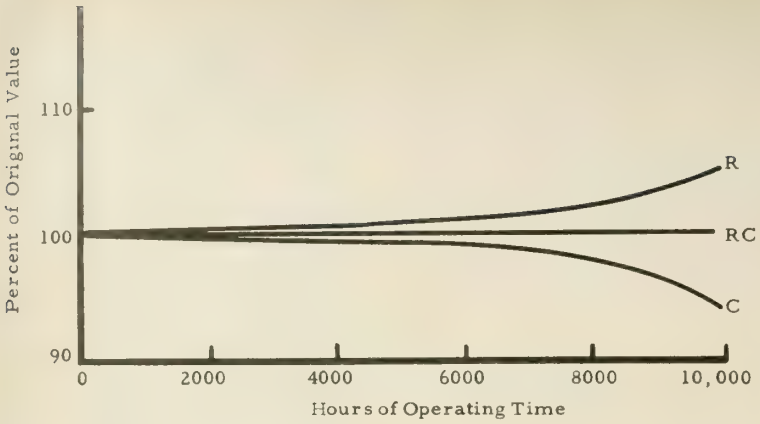


Figure 5. Per cent deviation in component characteristic for operation at 100 per cent and 50 per cent of rated load.



Code:

R - Resistance

C - Capacitance

Figure 6. Drift trade-off in R-C circuit.

lower than when relatively little drift is anticipated.

Control and Test Engineers

Quality control and test engineers can utilize the wealth of information in failure rate and characteristic drift curves, failure analysis data and screening techniques for design of test procedures and to substantiate test results. This information would indicate which tests are likely to be most effective for a particular component type and provide confidence in the test results from a small sample when correlated with the accumulated reliability data. The shape and duration of the infant mortality period of the failure rate curves are important factors in the selection of production tests, for it is quite conceivable that these tests could decrease rather than increase the equipment reliability if the components were inadvertently overstressed.

In conjunction with the purchasing department and application engineers, quality control and test personnel could apply their combined knowledge to the design of procurement and acceptance specifications to assure that the components which are ordered and received for production use meet the required standard of reliability.

Field Service Engineers

Preventive maintenance is a necessary adjunct to the present complexity of electronic systems, and requires a vast pool of highly trained personnel to assure continued equipment operation. Many of these maintenance programs consist of a systematic removal and replacement of equipment components before their useful life has been achieved.

This may not be good practice for two reasons: the first and most obvious is the expense involved for labor and materials; and the second and more important is the danger that the replacement part is not as reliable as the original, or that the replacement technique, such as soldering, has introduced another factor of unreliability.

By applying the knowledge that can be obtained from failure rate curves, preventive maintenance programs could be streamlined or realistically redesigned. Utilization of marginal testing techniques could also be an important factor in these programs to determine when a component needs to be replaced.

The road to reliability lies in the proper engineering application of component parts. These are the basic building blocks of our electronic systems; but before they can be intelligently applied, we must know their strong points and weaknesses, their failure and shortcomings.

Where can reliability information be obtained? Valid, but limited, component capability data is available in reports such as those prepared by ARINC, Vitro, BuShips, etc., and in some cases in component manufacturers' literature. But the scope of this endeavor must be greatly broadened if the degree of reliability necessary for today's complex systems is to be achieved. A concerted attack must be made on the "reliability barrier" by exchange of information among manufacturers and by systematic preparation of handbooks such as those available in the mechanical and structural engineering fields.

The task ahead is formidable, but by no means insurmountable. To attain our goal—elimination of the reliability barrier—industry and government agencies must sponsor the preparation of electronic component handbooks. Furthermore, the entire team, from designer to field service engineer, must become well-versed in the proper utilization of component capability data. ★

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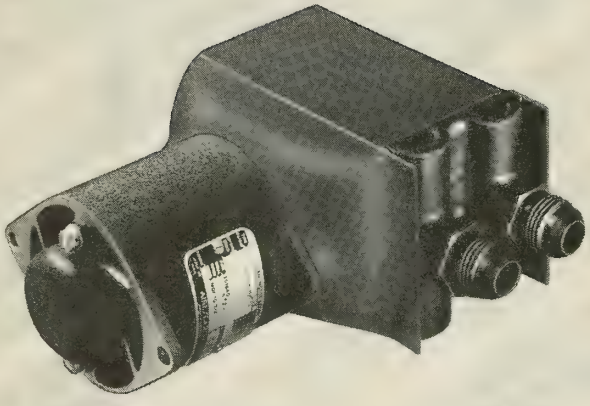
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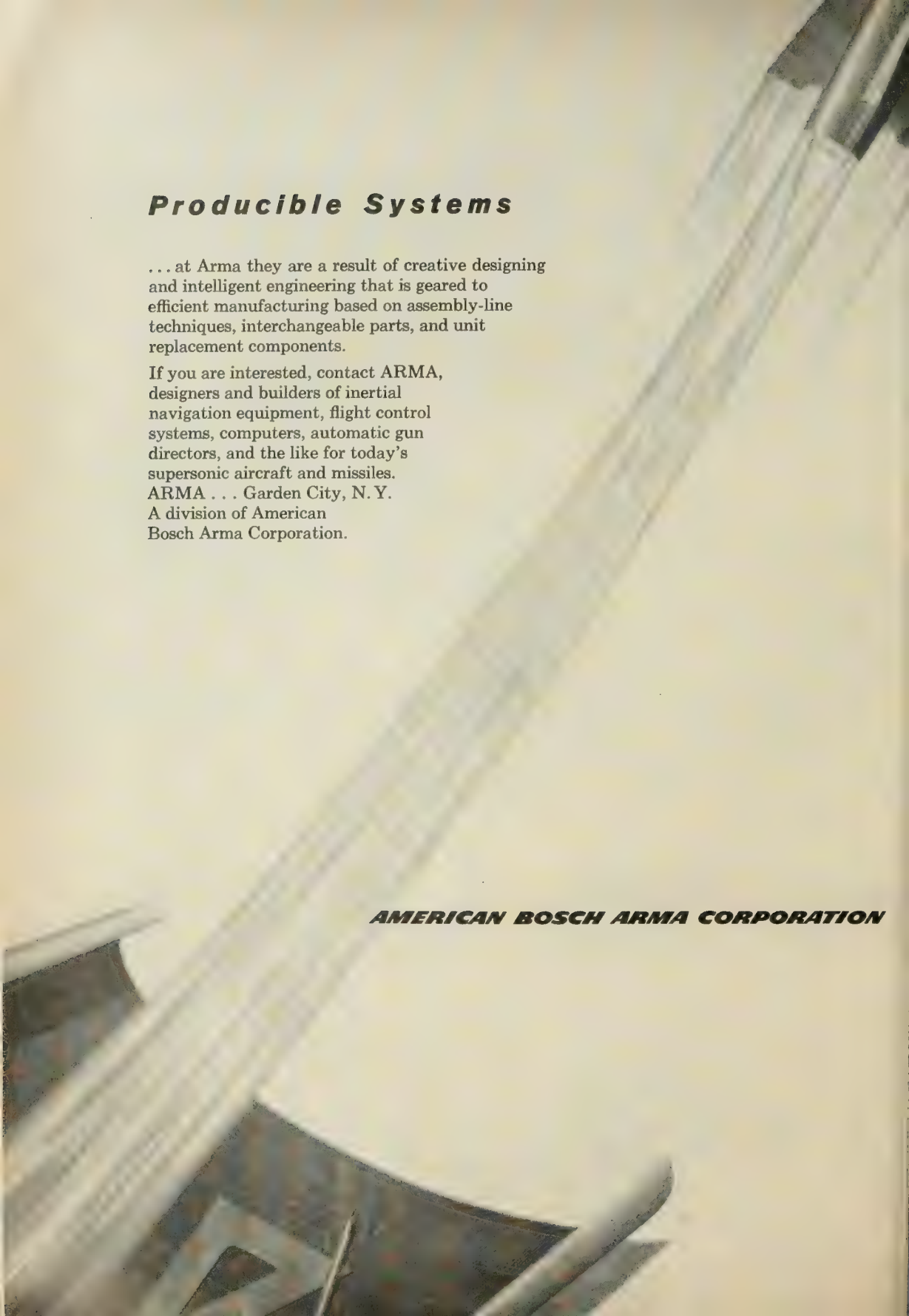
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ICBM and anti-missile missiles force reassessment of measurement technique

new missiles strain test art

by Henry P. Steier

PERFORMANCE REQUIRED of present-day missiles has begun to strain the capabilities of available astrionics instrumentation to check performance. This condition will be aggravated when flight tests on ICBMs and anti-missile missiles get under way in the near future.

Much of the success of future missile programs depends on more rapid strides in the field of electronic trajectory-measurement systems for missile tests, according to a paper delivered at the Western Electronic Show and Convention by Vernon L. Miller, White Sands Proving Ground, N. M.

"The task of instrumenting the present and planned missiles presents some nearly insurmountable problems. The expense involved in missile tests and the shortage of range time precludes the firing of large numbers of missiles with a hit-or-miss evaluation technique. The least expensive and most expeditious course is to fully instrument a limited number of missiles. Some of the problems placed on the present systems are quite severe. It is these more severe requirements that present today's problems, and these are the problems which must be solved if missile development programs are to attain success while remaining within reasonable development times."

Typical Future Requirements

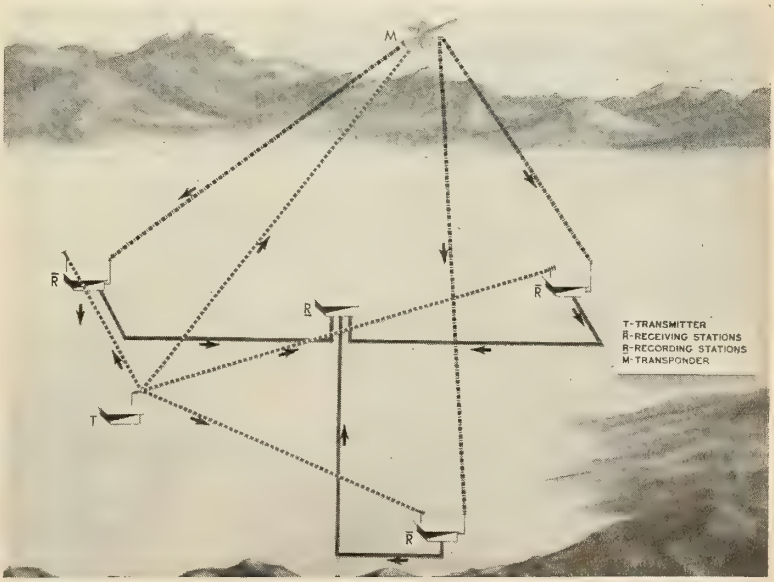
The precision with which the burnout conditions of an ICBM ballistic missile must be measured typifies measurement conditions facing designers.

If the missile has a 5000-mile range with a circular error probability (CEP) of one mile, a velocity measurement error of one meter per second or an angular measurement error of 0.01 degree is excessive to the performance design tolerance of the missile.

Such tolerances would give a measurement error greater than the specified CEP of the ICBM. Added to the close measurement required is the handicap of making the measurement hundreds of miles from the nearest instrumentation facility. Even with short-range missiles, the difficulty is present since these may have smaller specified CEPs.

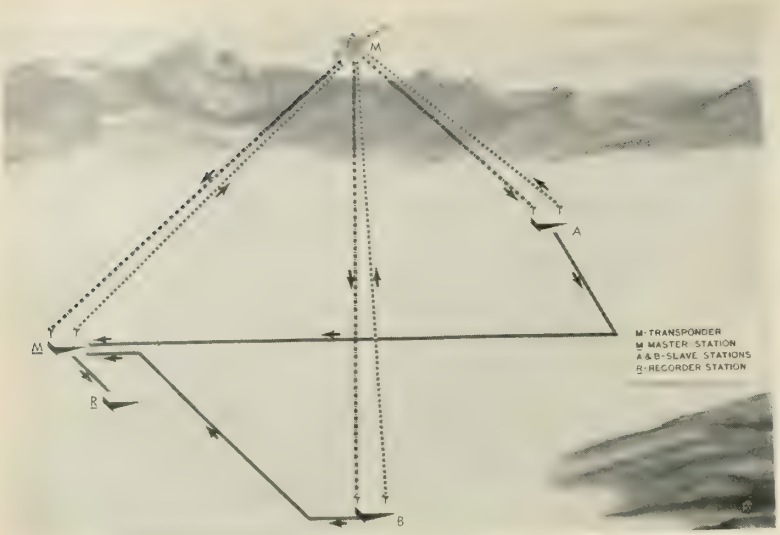
Instrumentation of the anti-missile missile goes beyond ICBM requirements. Measurement of needed miss-distance data will be strained by the high closure rates. Miller says these will be in excess of Mach 10, and it will be "next to impossible to predict within 25 miles or more where the encounter will occur."

Add to this the safety problem. High maneuverability is needed in ad-



Electronic trajectory measuring system using Doppler effect. In missile, signal is doubled in frequency and sent to receiving stations for analysis at different positions.

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Phase measuring system. Stations send and receive a signal in sequence. Phase shift is proportional to change in path length. Station gets independent readings.

dition to high speed. Position data required during an anti-missile missile test flight must be not only highly precise but instantaneously available to prevent the anti-missile missile from going hundreds of miles off course and doing damage in event of guidance-system failure.

The high-altitude research rocket presents its own stringent problems. Necessary accuracy for position might be within one meter, and velocity within 0.1 meter per second while the vehicle is at 200 miles altitude.

Such measurements mean obtaining accurate data within three parts per million. On an angular basis it amounts to measurements within 0.6 seconds of arc.

Basic Techniques

At this time there are about 30 electronic trajectory systems in use or in development. A basic similarity between the systems is measurement of radio-signal propagation time. The measurement is done in different ways. These form different geometrical configurations of data-acquiring equipment stations.

Combinations of measurement methods are selected for applicability to different tests depending upon parameter accuracy, degree of automation and logistic needs.

What the trajectory systems provide is a time history of the missile flight path. This is in the form of space-position data with velocity and acceleration derivatives.

These data are used for post-flight analysis of missile performance, or for control of missile while in flight. Latter applications might be for real-time trajectory measurement for flight-safety control, miss-distance measurement, navigation when missile data sites are shipborne or airborne, or real-time systems that are part of a control loop.

Measurement of propagation time is done in three ways: pulse time, frequency measurement, phase measurement. Systems in the vehicle may be passive or active-passive requiring no transponder, or active requiring a transponder. Another (hybrid) system requires no transponder but uses an rf signal generated in the missile to operate a telemetry transmitter.

Ground systems may be of multi-station type where stations are distributed over a test range to give the required geometry, or a single-station which yields all measurements to obtain trajectory data.

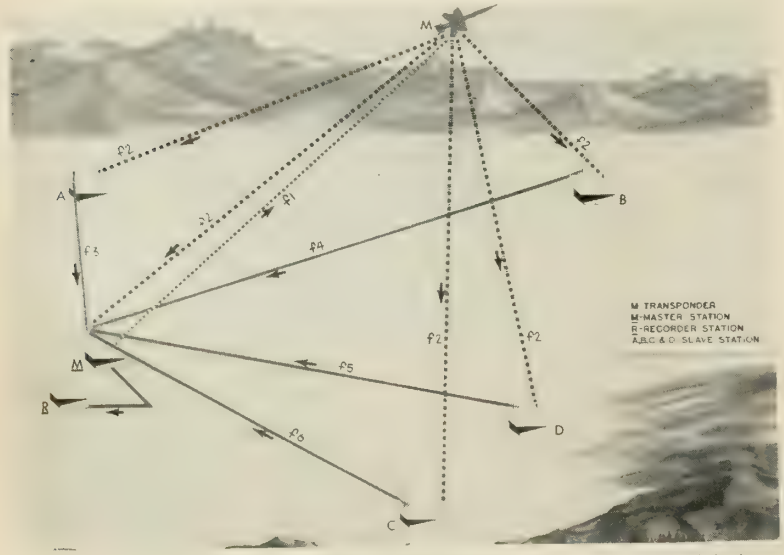
Although categories of trajectory systems based either on geometry or measurement techniques are not distinctive, they may be arbitrarily divided in four groups: Doppler phase measurement; pulse time measurement; interferometer.

Present Systems

Some factors to be considered before a trajectory measurement system is selected are:

- Can the missile accommodate a transponder and antennas?
- What is the trajectory? Accuracy and resolution of systems are different for different trajectories.
- What is stability and accuracy of data derivatives? A system may produce medium-accuracy position data and high-accuracy velocity data or the reverse of this.
- Cost balance between expensive single-station systems and lower cost available multistation systems.
- Data transmission costs for multistation systems.
- Is real-time data needed or will rapid data-reduction techniques suit the need?
- What are the frequency requirements? Spectrum availability, interference and propagation problems must be met.

Two of the most common Doppler systems are DOVAP and TRIDOP. Known as "elliptical" systems, they use the principle of detection and integration of Doppler frequency shift resulting from missile velocity.



Radar triangulation pulse time system. Pulse-modulated carrier is frequency shifted in missile. This signal is again shifted by slave stations and sent to master station.

A high-stability rf signal is sent to the missile from a ground reference transmitter. The signal is received by a transponder in the missile and a number of ground based receivers.

In the missile the signal is doubled in frequency and retransmitted to the ground receivers. Comparison of the original and doubled signal gives a Doppler "beat." By integrating this signal a loop range representing distance from transmitter to vehicle and back to the receivers is obtained.

The loop range is a non-directional quantity and describes ellipsoids of revolution with the transmitter and receivers as foci of the ellipsoids. By solving for the intersection of three or more ellipsoids, space position of the missile is determined. By successively differentiating the position data, velocities and acceleration at different points are obtained.

There are other Doppler systems such as PARHOP, which uses no transponder but depends on reflection of a continuous wave signal. SPHEREHOP eliminates the transmitter-to-missile link by using a very stable oscillator in the missile. Reflection Doppler uses a single station to derive velocity data only.

Among the phase measurement systems are ROMOTAR, SECOR, and DORAN. Station configuration for these can be similar to DOVAP's. Geometry of the system may be elliptical or spheroidal. With these a group of ranging frequencies modulate an rf carrier sent from a master station. The signal is received in the missile and at ground receivers. In the missile, the rf carrier is offset in frequency and retransmitted. The frequencies received from the missile by the ground receivers are different in phase from those received by the master station.

Phase shift is proportional to changes in path length throughout the trajectory. Using four or five modulating frequencies, high precision, non-ambiguous readings may be obtained over long ranges.

Another of the phase-measurement systems uses a transmitter and receiver at each ground station. Controlled sequencing of transmissions is used and each transmitter interrogates the missile in turn. Each station obtains a range measurement and missile position is determined from the system of spheroidal loop range data obtained.

Pulse time systems are basically applications of radar technique. They are based on transit time of a pulse from a ground transmitter and return. One of these is the radar triangulation MIRAN system.

With MIRAN a pulse-modulated carrier is sent to a missile. The missile receives it, shifts the frequency and retransmits the signal to slave receiving stations on the ground.

The slave stations offset the received frequency and beam the signal back to a master station. At the master station the times for transit of the pulse from the missile to each of the slave stations is measured. Missile position is obtained by solutions similar to previously mentioned systems.

Some of the electronic interferometer systems are MINITRACK, COTAR and EMA. MINITRACK will be used to track the satellite launched from the Project *Vanguard* vehicle. Such systems perform angular measurements by comparing phase of a signal received from a missile at two antennas mounted on a short baseline.

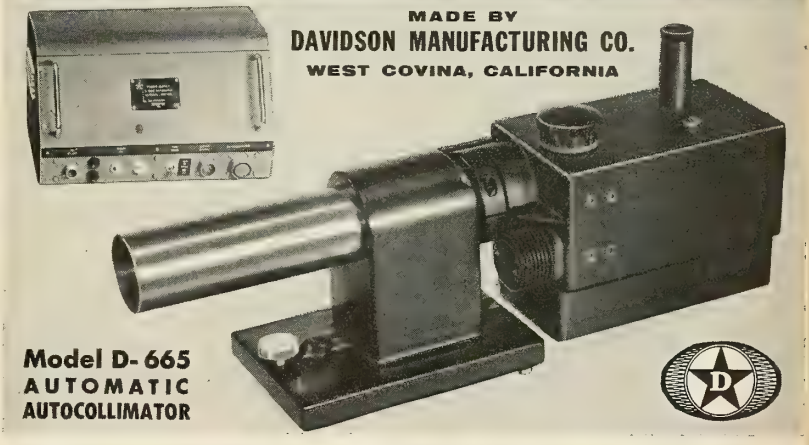
The phase difference is related to the direction cosine of the angle. To obtain high precision and ambiguity resolution, multiple antennas are used on short and long baselines. Also, by crossing baselines two direction cosines are found from which azimuth and elevation angles can be obtained.

If such a facility is combined with a means of range measurement of the Doppler or phase measurement type, the system becomes a single-station system. Sometimes two or more angle measurement stations are set up on a long baseline to permit triangulation for obtaining position, velocity and acceleration data.

The EMA system is not a trajectory measurements system but gives

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low-precision information so optical instruments may receive the vehicle being tested.

Future Systems

There are other systems available which, because of security, cannot be discussed. Others are under development. However, to get the utmost out of any system and to select one that will do a particular job, considerable system analysis is required before it goes into use.

According to Miller the trend in the past few years has been to specialization in error analysis of trajectory systems. This work is aimed at verifying measurement precision. These tests must often be dynamic, involving actual missile flights.

At this time the study of errors is directed to simplification of analysis by obtaining a mathematical method for describing the geometry of various systems. A mathematical approach will show which systems of geometry are best for exploitation.

After that, precision figures could be obtained for every conceivable technique. This would result in a tabulation of statistical figures for application to system selection.

This information would enable rapid selection of a particular geometric configuration to satisfy a given set of parameters established by the missile in question and reveal what must be learned about it.

Other problem areas that must be included in the new analytic tool that will become available are effects of ionospheric refraction, flame attenuation of electromagnetic radiation, ionization shields around high speed missiles and effects of atmospheric noise.



Interferometer system similar to MINITRACK, using two stations to measure phase difference at multiple antennas. Two-station system gives position, velocity, acceleration.

Another trend in this field is consideration of measurement system requirements at the time a missile is conceived. Specific provisions are being made in designs to include necessary instrumentation as part of the system design.

Miller predicts that we will ultimately have measurement systems in which trajectory, telemetry and real-time control are a single integrated system. ★

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Special dust-free labs required in the development of air-bearing gyros

air-lubricated gyros

By Norman L. Baker

THE DEVELOPMENT of the guided missile has opened many new fields of engineering. New approaches to the engineering field have led to the rapid growth of new techniques. This applies particularly to the technology associated with ballistic-missile guidance, which is spearheaded by the Missile Development Division of Ford Instrument Co.

This group is currently engaged in work on two missile programs for the Army Ballistic Missile Agency at Redstone Arsenal. The first of these programs involves the *Redstone* missile and the other, the *Jupiter* missile.

In nearly five years of engineering and manufacturing effort, a highly successful product-improvement program on missile guidance and control components has been achieved, in particular on the Redstone Arsenal-developed air-bearing stabilizing gyros and air-bearing gyro accelerometers. These air-bearing devices are major components of the stabilized platform used as the nucleus of the navigation system of the *Redstone* missile.

The air-bearing gyro and air-bearing gyro accelerometer were developed by Redstone Arsenal and adapted for production by the FICo, the only company in the U. S. that manufactures such a gyro.

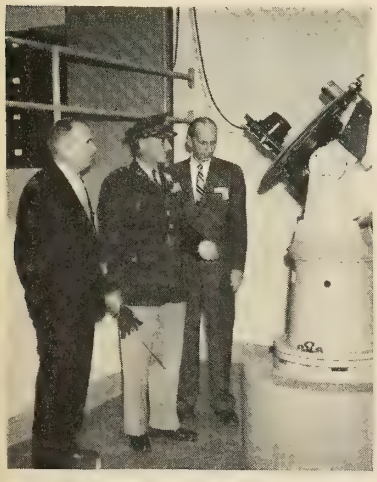
At the present time, work on the *Redstone* missile program includes an evaluation and improvement program aimed at determining the extent to which the guidance and control system components will withstand the rigors of military storage, handling and firing. Components are subjected to the most severe climatic and environmental conditions they will face during storage, handling and firing by the Army's own personnel. Invariably, these environmental tests demonstrate weaknesses in design which can only be detected by semidestructive environmental testing.

Early in 1956 FICo launched the second of its ballistic missile programs. The character of the *Jupiter* engineering effort now in progress differs markedly from the current *Redstone* missile work. While the *Redstone* project has progressed to the point where existing designs are continually improved and reimproved, the *Jupiter* work involves the formulation of the first designs of experimental missile hardware. However, much of the theory underlying *Redstone* guidance, and much of the experience gained in developing guidance and control equipment for the *Redstone*, is directly applicable to the *Jupiter* missile work

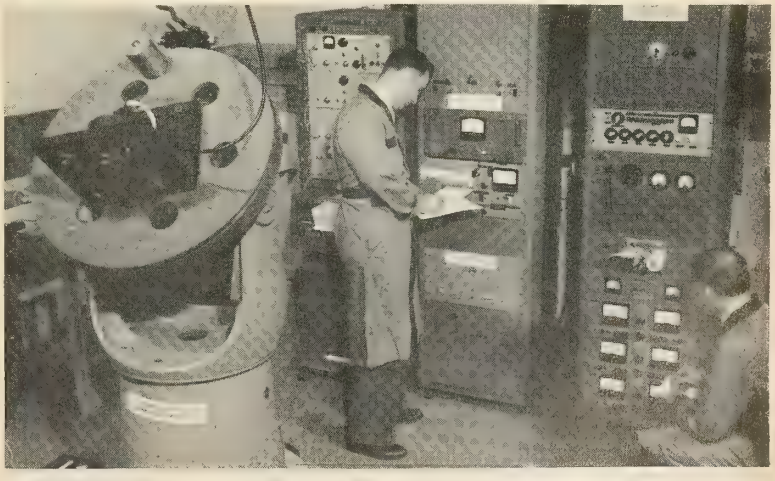
A modern gyro-test lab was set up to evaluate and measure the accuracy of the ultrasensitive air-bearing gyroscopes used in the *Redstone* and *Jupiter* guidance systems. Experience has shown that even the smallest dust particle could create an unbelievable amount of friction torque in the presence of ultraprecision gyroscopes. With this uppermost in the minds of the planners, the lab was designed to be one of the cleanest and most dustproof in existence.

The completely enclosed laboratory is windowless and has a minimum of horizontal surfaces. Extra plaster was applied to areas between ceiling and walls to round off what normally would have become right-angled dust-collecting spaces. All wires are hidden within the walls and receptacles and fixtures are flush with the walls. Floors, ceiling and walls are smooth and clean. A specially-treated dust-absorbent mat covers the area between the vestibule and the outside door.

In the vestibule are lockers for changing clothes. Employes working in the gyro lab must remove their shoes before entering through the heavy, win-



Larry Brown, FICo, ABM9 Gen. Medaris and Raymond Jahn, Pres. FICo, visit gyro lab.



Engineers examine air-bearing gyro drift data that has been recorded by drift-rate measurement apparatus. Equipment will measure angular drift rates of one revolution in 40 years.



Engineer installs an air-bearing gyro on sensitive equatorial test stand in FICo test lab.

dowless double doors opening into the main work area. They must wear special, lint-free white coats.

Sheet linoleum was selected for floor covering, since tile and many other materials would have been broken up by dust-collecting crevices. A dustproof public-address system is housed in the ceiling for convenient interlab communication. This eliminates any unnecessary traffic through the lab.

Eating, drinking and smoking in the work area are taboo. No "unnecessary" tools or equipment may be brought into the lab, mainly to keep out additional potential dust carriers. Consideration is being given to the drilling of a periscope-type device through the outside wall so the night watchman can inspect the area without danger of carrying dust inside the lab.

Daily all surfaces, such as desk and bench tops, are vacuum-cleaned, using a brush attachment. Plastic waste baskets of the dustproof, washable type are used and are emptied outside. Glass surfaces are cleaned with a moistened cellulose sponge rather than with a dust cloth or broom. All floors are cleaned with cellulose mops.

All walls and ceiling areas of both main laboratory and vestibule are vacuum-cleaned. They are also cleaned with a cellulose sponge using warm water and a mild detergent. Every effort is made to prevent the water from dripping. The floor is waxed with a cellulose-sponge attachment using a special dust-resistant mixture.

Porters wear white coats, white gloves and moccasins over their shoes when working in this area. But no gloves are worn during any washing procedure. Equipment belonging to the lab porters is thoroughly cleaned after use before re-storing in special lockers. Periodically the inside of the duct work for the air conditioning and heating systems are vacuum-cleaned.

Outside experts were called in to further insure that the area be free of dust. The finest available separately controlled air conditioning and heating plants were installed in a room directly below the lab. The air conditioning features a special-type filter often used in Atomic Energy Commission work. It is believed to be the most completely dust-free filter yet made.

An air compressor was purchased to provide the gyro lab with clean, dry, filtered air free of contamination and oil vapors. This is the same type of air compressor used to supply air for hospitals. A special air dryer has also been installed.

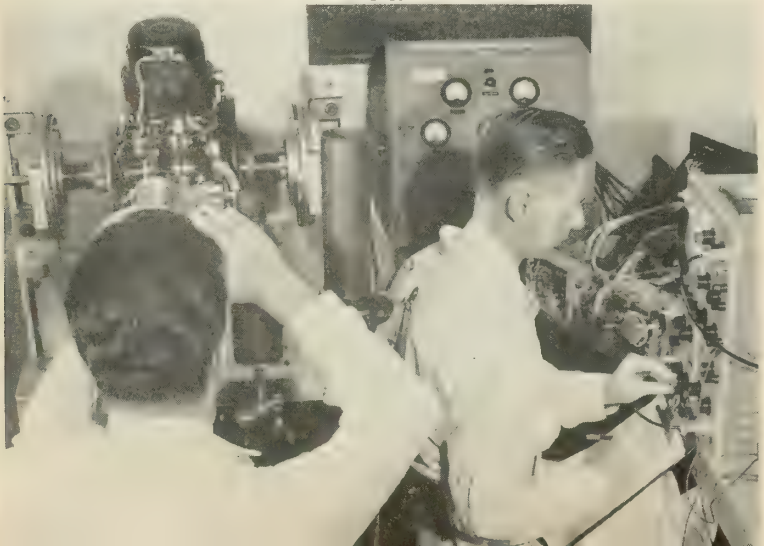
Temperature and humidity controls were built into the walls to provide complete control of temperature and humidity for the extremely sensitive gyroscopes being tested.

The lab was located in an area of the plant where building vibrations from any cause were minimized. Simple tests with a pool of mercury and a vibration meter helped determine the most vibration-free site. The area also had to be soundproofed to reduce the noise coming from high-speed rotating machinery used to test the gyros.

The Coast and Geodetic Survey, which specializes in precision mapping of the U. S., was called in to establish a line between two bench marks. From that line the engineers were able to orient a rotating test stand so its axis was parallel to the earth's axis.

FICo expects this lab to play an increasingly vital role in the current era of guided missiles and the not-too-far-off era of space travel. ★

Measurement of drift rate of the air-bearing gyros in the REDSTONE's guidance system.



thermocouple application for ballistic missiles

Temperature measurements are accomplished by thermocouples in Redstone and in Jupiter

By Charles T. N. Paludan
Army Ballistic Missile Agency

THE MOST RELIABLE temperature measurements that can be made on a ballistic missile, from a mechanical standpoint, involve the use of thermocouples. A thermocouple measuring junction can easily be located at practically any point within or on the missile. This is not always true in the case of resistance thermometers, thermistors, gas, vapor pressure or bimetallic thermometers.

In many cases a thermocouple installation may be exceedingly rugged. At the present state of the art the insulation resistance problem gives the thermocouple a decided advantage over resistance-type measurements at high temperatures.

Three primary problems are associated with thermocouple measurements: (1) low output, (2) lead resistance and resistance change, and (3) the reference junction temperature.

The low output problem can be solved by means of a stable, high-gain DC amplifier of the magnetic, chopper, or transistor type. As most thermocouple materials have a high resistivity and a high temperature coefficient of resistance, large errors are possible if long leads and severe environmental temperatures are involved.

This error could be minimized by avoiding long leads of thermocouple material, changing over to low-resistance copper wires for the major portion of the distance. This could be done by placing the reference junction near the measuring junction.

The reference junction temperature must be determined in order to evaluate the output of a thermocouple system in terms of measuring junction temperature. This is commonly done in the laboratory by immersing the reference junction in an ice bath or, for less precise work, by determining the reference junction temperature by means of a mercury-in-glass thermometer.

Industrial and missile applications, involving the use of meters or recorders, make an automatic or semiautomatic correction for ambient temperature changes by means of a bimetallic device, a thermistor, a resistance thermometer, or a moving vane. Slide-wire potentiometers are often equipped with similar devices.

Another method is to maintain a fixed, higher-than-ambient temperature within a small oven. A much simplified but far less elegant method would be to imbed the reference junction in some material of high heat capacity, measure the temperature with a mercury-in-glass thermometer, and assume no change for a given length of time.

Oven devices have been used extensively and are available commercially from a number of manufacturers. One such device, developed for the Army Ordnance Corps by members of the Chrysler Corporation's missile branch, has been used for a number of temperature measurements in the *Redstone* missile (Fig. 4).

This device, although successful, did not eliminate the problems of long thermocouple leads, the need for thermocouple material connectors, and the inability to read temperatures below the oven's set temperature. Furthermore, the oven acted as a heat source which was sometimes troublesome when it was operated near temperature-sensitive equipment.

In order to prove that all temperature-measuring equipment was func-

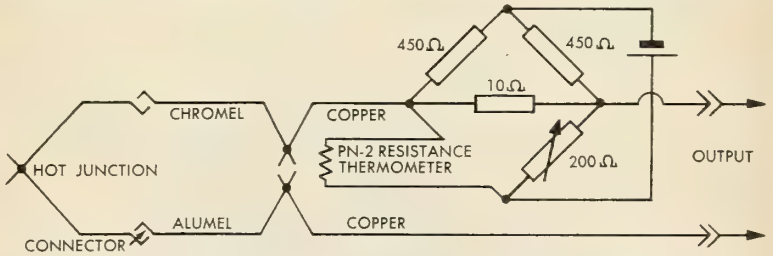


Fig. 1—Circuit diagram of first reference junction system for the REDSTONE missile. The ambient-temperature-sensing thermometer dictates proper correction into the system.

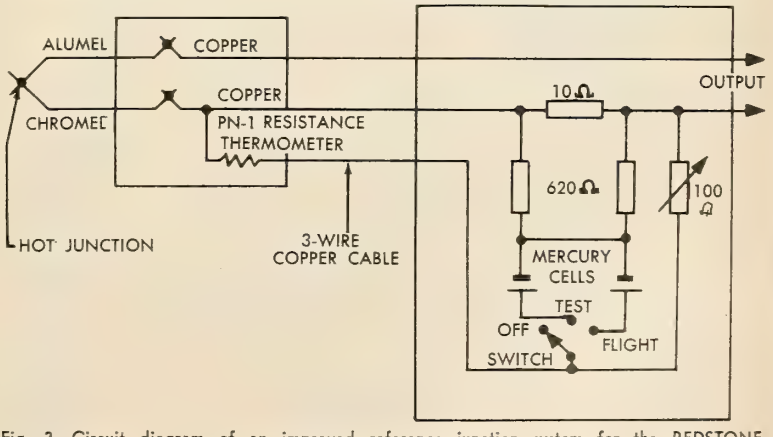


Fig. 2—Circuit diagram of an improved reference junction system for the REDSTONE. Dependability of the system is largely a function of the stability of the mercury cell.

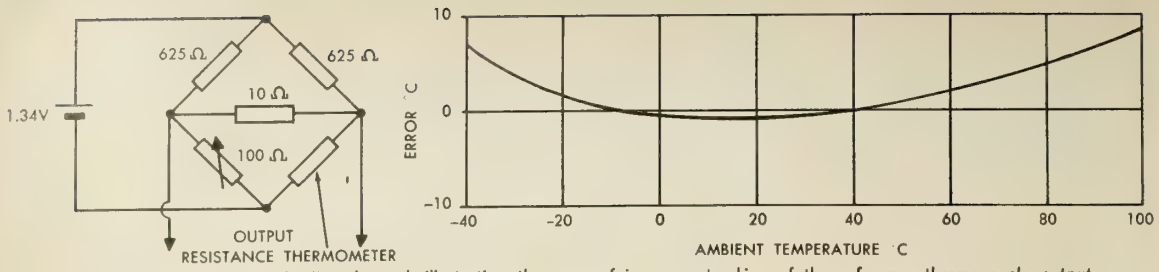


Fig. 3—Circuit diagram of "zone box" and graph illustrating the error of improper tracking of the reference thermocouple output.

tioning properly before a missile launching, it was necessary to read the ambient temperature which was usually on the order of 25°C. Many of the measuring points were inaccessible for external heating.

An actual ice bath reference would be impractical for missile use because of the difficulty in servicing it. Furthermore, it would not eliminate the extension lead problem of the scattered measuring points. A series thermistor compensator would be difficult to devise because the impedance of the amplifier system would vary for different ranges of measurement. A series thermistor device would still give zero output at ambient temperature, an undesirable condition.

Basically, the reference junction problem is one of knowing the reference junction temperature. As this knowledge is useful only as a correction, it would be sufficient if the correction were made directly in the measuring system.

If the reference junction is to be at ambient temperature with no resort to ice or oven, and is to be located near the measuring junction, the ambient temperature must be sensed at that point. The ambient-temperature-sensing organ would then dictate the proper correction into the system. As the required correction is electrical, a resistance-changing sensing organ is needed. Inexpensive resistance thermometers are available which will serve the purpose.

Figs. 1 and 2 are circuit diagrams and essential parts of a system meeting the requirements just outlined. Fig 1 depicts a system which has been used for several hundred measurements in the *Redstone* missile. Fig. 2 is an improved version for use in the *Redstone*.

As can be seen in the circuit diagrams, the resistance thermometer senses the reference junction temperature, operates into a deflection-type wheatstone bridge which draws power from a mercury cell, and applies a correction across a ten-ohm load resistor which is in series with the overall thermocouple circuit. The error introduced by the series ten-ohm resistor will be negligible if the impedance of the amplifier system is sufficiently high. At any rate, it can be calibrated out.

The dependability of the system is largely a function of the stability of the mercury cell. It is desirable to use a fresh cell for the missile's flight, because check-out procedures at the launching site may have exhausted the energy of the original cell.

In most cases the measuring junction is in direct contact with some metallic part of the missile. This makes the junctions electrically common. For this reason a separate compensating system and mercury cell are required for each measurement.

The original equipment shown in Fig. 5 required mercury cell servicing at each installation point. In some cases this would be an advantage; however, the complexity of a large missile system such as *Redstone* or *Jupiter* makes the task of battery replacement rather formidable. For that reason the new system (Fig. 2), with its centralized batteries was evolved. In either case the individual cell lifetime would be several weeks.

Utilizing an adjustment potentiometer, the reference setting may be varied so as to give artificial reference temperatures at levels other than 0° C. In that way it is possible to make thermocouple temperature measurements with elevated or depressed temperature levels of zero electrical output. For example, a measurement might have a span from −50°C to +500°C, in which case the thermocouple com-



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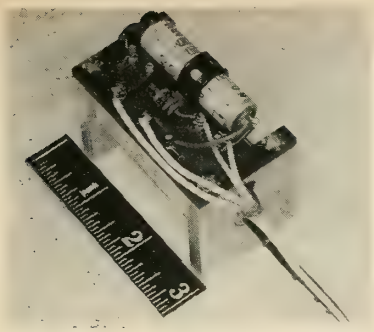


Fig. 4—Oven device for temperature check.



Fig. 5—REDSTONE reference junction system.

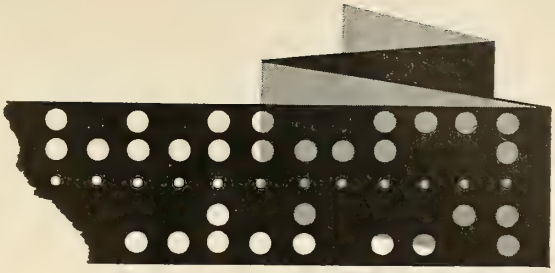
pensator system would have zero millivolts output at −50°C.

The accuracy of the system presented here depends on the ability of the resistance thermometer-bridge system output to track the output of the actual reference junction thermocouple. As the load resistor of the bridge is in series with the output of the system, it must be kept small—about ten ohms.

The voltage supply to the bridge is fixed by the potential of a single mercury cell. Series cells are ruled out for reasons of reliability. In order to obtain sufficient output from the bridge, the ratio of the high to low resistance arms of the bridge is somewhat small with the result that the bridge output is unlinear. Therefore, the compensator circuit does not track the reference thermocouple output perfectly. However, the tracking is sufficiently close for most practical purposes over a considerable span of ambient temperature. Fig. 3 illustrates the error resulting from improper tracking.

The system described has been given the name "zone box." The name was suggested by the fact that the unit includes a zone of equal temperature for the reference junction thermocouple and the resistance thermometer.

Development work on the zone box was done in the RF, Telemetering and Measuring Section of the Guidance and Control Laboratory, Army Ballistic Missile Agency, Redstone Arsenal. ★



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Applied mathematicians and engineers are needed as computing analysts for assignment to Northrop's analogue computing facility, as well as their enlarged digital electronic computer department which provides unparalleled service in the practical solution of complex engineering problems.

Your assignments will be fresh and stimulating, and you will have frequent opportunities to advance in your field. Besides an excellent salary, you will receive company-paid benefits that are unexcelled in the entire aircraft industry. Your colleagues will be the brilliant engineers who developed the USAF-Snark SM-62 intercontinental guided missile and the new USAF-Northrop T-38 supersonic twin-jet trainer. These men are congenial and helpful, and will respect your ability and individuality just as Northrop expects them to do. And you and your family will fully enjoy Southern California's many attractions and its delightful all-year climate.

If you qualify for any phase of computer research, design, or application, we invite you to contact the Manager of Engineering Industrial Relations, Northrop Division, Northrop Aircraft, Inc., ORegon 8-9111, Ext. 1893, or write to: 1041 East Broadway, Dept. 4600 R, Hawthorne, Calif.



NORTHROP

Northrop Division of Northrop Aircraft, Inc.

BUILDERS OF THE FIRST INTERCONTINENTAL GUIDED MISSILE

5-A-143

Long Range Telemetering Transmitter

The demand for extra radiating power near the terminal phase of missile flights has led to the development of a small transistorized 200-watt transmitter with an extended range.

It is in the terminal phase of flight that many unpredictable problems occur, and until now this has been the very region in which background noise has blacked out the weakening telemetered signal. Stepping up transmission power will override background noise and extend transmission range considerably beyond line-of-sight limits imposed by present transmission equipment.

Transistorized to the practical limits of the state of the art, the new 200-watt PM transmitter was developed by the apparatus division of Texas Instruments Inc. It increases substantially the effective range of FM FM telemetering. The new equipment is complete in a single unit and requires no amplification of the output. It is small and lighter than currently available 50-watt transmitters for similar duty, occupying only 67 cubic inches.

The new units transmit in the 215-235 mc range with frequency stability of plus or minus 0.01 per cent up to 71°C. Higher frequencies are possible with only minor modifications. The basic unit can also be modified to operate at power outputs as low as 25 watts. Operation at 200 watts requires 12 cfm external cooling air.

Thermal control

Integral "heat sink" provisions are ideally suited to missile requirements, stretching out the transmitter's operation during periods of rapid build-up—for example, during re-entry into the atmosphere. High-temperature silicon transistors are used in the oscillator, phase modulator, video amplifier, and frequency doubler circuits. The output stage utilizes a stacked ceramic tetrode with considerable excess capacity, and tubes are also used as drivers and multipliers.

Texas Instruments is also supplying components for the instrumentation package of the *Far Side* high-altitude test program now underway.

Plug-in Telemetry Units Explored by Seeburg

Telemetry systems with removable circuits that may be used in varying combinations to provide telemetering equipment for any missile test program are being developed by J. P. Seeburg division of Fort Pitt Industries, Inc.

Seeburg, developing the basic "building-block" components with its own funds, feels that the advantages of such a flexible telemetry system are almost unlimited. The individual plug-in circuits would also allow changing of functions within a missile's telemetry.

Radio Spectrum Study Approved by EIA Board

A cooperative long-range study of the radio spectrum, covering both military and civilian uses of frequencies, was approved in principle by the board of directors of the Electronic Industries Association at the conclusion of a three-day EIA conference in Los Angeles.

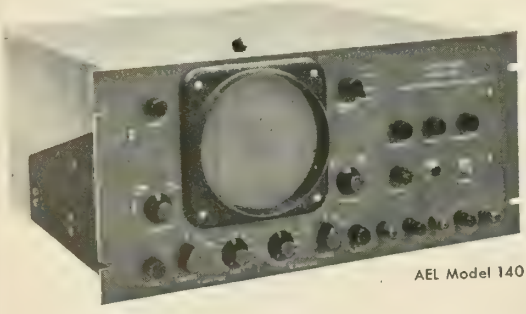
The proposal for the study emphasized that the radio spectrum is one of the most valuable national resources and that its full value can be realized only by means of frequency allocations based on comprehensive technical information.

Big Antennas Replaceable With Smaller Units

Two scientists of Bendix Aviation Corp.'s systems division have announced a technique whereby extremely large and complicated antenna structures can be replaced by much smaller and simpler structures.

The scientists, Dr. Winston E. Kock and Dr. Jack L. Stone, described an example where the beam of a parabolic dish 10 feet in diameter was duplicated by three small wide-band receivers arranged in an equilateral triangle, six feet on a side.

The technique is applicable to sonar underwater sound systems, radio astronomy and other forms of radio and radar.



AEL Model 140

Display Oscilloscope

A display unit for use as a dynamic indicator with ANALOG COMPUTERS, CURVE and FUNCTION GENERATORS, etc. The "140" is designed with very low values of hum, noise and drift specifically to enable quantitative measurements. No internal sweeps are provided.

- Built-in QUADRANT SWITCHING
- FLAT FACED TUBE 5ADP ( )
- Frequency Compensated Input Attenuators
- Z-Axis blanking
- IDENTICAL horizontal and verticle amplifiers
- 20 mv/inch, dc to 50 kc. (max.)
- Standard Rack Mounting
- ENGINEERED control panel

POWER 105-125/210-250, 50/60 cps
PRICE $425.00

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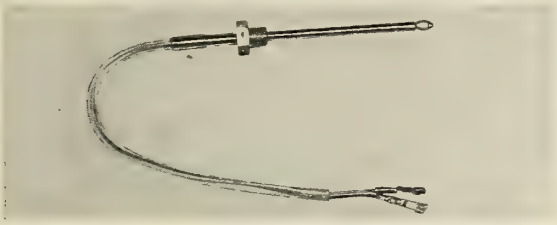
AEL

Circle No. 106 on Subscriber Service Card.

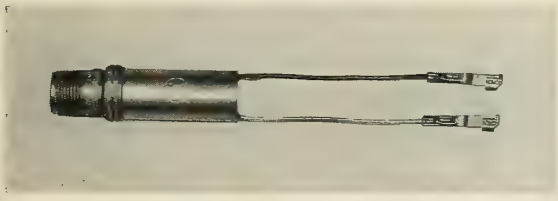
New Universal Temperature Measuring System

Rugged and reliable – extends use of thermocouples, eliminates icebath and oven references

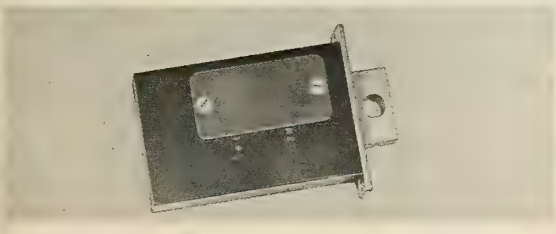
Simplified system accommodates all three gauge types. Magnetic-amplifier "heart" makes possible low-span thermocouple measurements up to 2000°C. Developed for a major missile program, system is fully flight-tested. Offers industrial uses, too.



Use of thermocouples as sensing elements boosts measurement level from 900°C to a new maximum of 2000°C. Characteristic ruggedness of thermocouples also increases system reliability. Thermistors or resistance thermometers may also be used as system requires.



Compact, inexpensive "zone box" (part no. 91-101-0) does away with icebaths and ovens by simulating exact reference temperatures electrically. Box mounts near thermocouple, thus eliminating long leads. It withstands extreme environments without losing accuracy. Since each thermocouple feeds into its own zone box, referencing is decentralized, system reliability and flexibility are further increased.



Zone box adapter (part no. 91-102-0) permits easy, precise adjustment of thermocouple reference to point desired. Adapter suitable for operation into low- or high-impedance instrumentation. Both adapter and zone box are manufactured by Magnetic Research Corporation to ABMA specifications.

Micromag MM 423 low-level dc magnetic amplifier is the virtually indestructible heart of the system. It is the stability of this unit that makes possible the use of thermocouples under severe operating conditions. Amplifier drift is less than .1% over 2000 hours. Voltage gain of 500 simplifies small-span measurements with any of the three gauge types. Unit is temperature compensated for high gain stability. Used with or without zone box and adapter, the Micromag ups reliability of temperature and strain measuring systems.



SPECIFICATIONS OF MICROMAG* MM 423 LOW-LEVEL MAGNETIC DC AMPLIFIER

Voltage Gain:	500
Input Resistance:	200 ohms
Drift:	Less than .1% over 2000 hours
Output:	0-5 VDC into 100 kilo-ohm load
Response Time:	80 milliseconds
Compensated Temp. Range:	0 to 60°C (can be extended to 85° upon request)
Environment:	—55° to 105°C
Power Source:	105-125 VAC, 400 CPS
Vibration, etc.:	Designed to meet MIL-E-5272 specs.
Volume:	Less than 7 cubic inches
Weight:	11 ounces

MM 424 Micromag Low-Level Magnetic DC Ampifier Same model as above. In addition, it provides its own DC voltage regulated to .1% to replace mercury batteries in Zone Box system or power bridge type measuring devices.

MMO 528 Micromag Low-Level Magnetic DC Amplifier Same as Model MM 423 above, but powered from unregulated 28 VDC system.

Write or telephone for technical information on MRC temperature-measuring systems and components. Our Engineering Department will be glad to discuss your special needs.

MAGNETIC RESEARCH CORP.
3160 West El Segundo Boulevard • Hawthorne, California

*REG. TRADE MARK

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*KG RELAY (Pat. Pendir

ONLY 2.0 WATTS AT NOMINAL VOLTAGE FOR 12 MILLISECONDS EFFECTS ARMATURE TRANSFE

NEW
POTTER & BRUMFIELD
KG SERIES RELAY

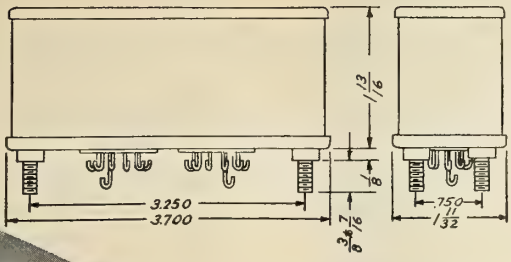
The new KG magnetic latch relay was designed by P&B engineers at the insistence of leading aircraft and missile manufacturers and their suppliers of control systems. A permanent magnet which locks the armature into position is the secret of the KG's dramatically high resistance to shock and vibration.

In addition to withstanding 30g vibration from 6 to 2000 cps, tests show the contacts will open for no more than 80 microseconds during 100g shock.

Armature transfer from one set of th 6PDT contacts to another can be made approximately 12 milliseconds with only 2 watts at nominal voltage. The KG is rate for ambient temperatures from −65°C t +125°C.

The KG, together with other relays in th P&B "Star Series", has vastly increased th realm of relay reliability for critical applic tions demanding positive action of all com ponents. Write or wire today for comple technical data.

POTTER & BRUMFIELD, INC., PRINCETON, INDIANA—SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPAN





STAR SERIES

KG RELAY

DESIGNATION: KG23D8H

GENERAL: Insulating Materials: Teflon, glass and ceramic.
Insulation Resistance: 100 megohms min.
Breakdown Voltage: 500 V. RMS.
Shock: 100g where contact openings less than 80 microseconds may be permitted.
Vibration: 30g 5 to 2000 cycles.
Ambient Temperature: —65°C to +125°C.
Weight: 13 ozs.
Pull-in-Speed: 12 MS using 310 ohm coil at 24 V. DC. (25°C).
Terminals: Two 11 pin multiple solder headers with hook ends for 3 #20/AWG wires.
Enclosures: Hermetically sealed only.
Dimensions: 1-11/32 x 3.700 x 1-13/16 (See drawing for width, etc.)
CONTACTS: Arrangements: 6 pole double throw.
Load: Dry circuit to 3 amps, 115 V. AC, resistive. 5 amps, 28 V. DC, resistive.
COIL: Power: 2.0 watts at Nominal Voltage.
Duty: Either coil may be left energized without damage to the relay.
Insulation: Teflon tape.
MOUNTINGS: Four ⅜ inch #8-32 studs on 3¼ x ¾ inch centers.

COIL DATA:(EACH COIL)

Voltage:	6 V. DC	12 V. DC	24 V. DC	48 V. DC	110 V. DC
Resistance: ±10% @ 25°C	14 ohms	55 ohms	310 ohms	835 ohms	5500 ohms

Potter & Brumfield, inc.
PRINCETON, INDIANA

Subsidiary of AMERICAN MACHINE & FOUNDRY COMPANY Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.



Mail the coupon below for further engineering data on P&B's new Star Series relays *plus* new compact catalog of standard type relays. If you need answers to a specific application problem, write in detail.

Potter & Brumfield, Inc., Princeton, Indiana
Attn: T. B. White, Brig. Gen. M.C. (Ret.)
Special Projects Engineer

Please send me complete data on the new Star Series relays, plus the new compact catalog of P&B standard relays.

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*Company*_____

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industry briefs

Northrop Creates Nortronics Division

Northrop Aircraft, Inc., has created a new division, to be called Nortronics, which will handle the company's operations in the design, development and manufacture of electronic, electro-mechanical and opto-mechanical products and components.

The establishment of the new line operating division will enable the company to collect its work in these fields under a central detailed management. In creating Nortronics, the company elected Dr. William F. Balhaus a vice president of Northrop Aircraft, Inc., and assigned him duties as general manager of the Nortronics Division.

Babcock Opens Facility To Consolidate Plants

Babcock Radio Engineering, Inc., has opened a new facility at Costa Mesa, Calif. The 25,000-sq. ft. in plant area will allow consolidation of all the company's divisions in a central location.

Babcock is producing drone guidance and electronic ground support equipment for Beech and Radioplane drones and also for several leading missile programs.

Micronics Gets R&D Contracts

Three research and development contracts covering guided missile components have been awarded to the Micronics division of Elgin National Watch Co. The new contracts total approximately $500,000 and have been assigned to the division's West Coast R&D laboratories at Burbank.

Atomichron Contract Awarded to National

National Co., Inc., communications equipment and atomic clock manufacturer, has received a $609,525 contract from the Army Signal Supply Agency for development of military-type atomichrons. The device is used for super-accurate timing involving missile guidance.

Era Engineering Gets Development Contract

Era Engineering, Inc. has signed a contract with Douglas Aircraft Co. for development of an in-flight instrument to measure thickness of a material sample. The material erosion rate instrument is transistorized and withstands high acceleration loads.

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complete electronic and mechanical assemblies

Encompassed in the scope of Erco's manufacturing operations are standard and custom-designed electronic and mechanical assemblies.

Long experience in the sheet metal and electronic industries has made Erco expert in both fields of endeavor. Illustrated above are two custom-built racks complete with electronic assembly ready for insertion into a trailerized* computer. These units are indicative of the precision electronic assembly and intricate metal working carried on at Erco.

You'll find that it is economical to consult Erco for the design and fabrication of complete electronic and mechanical assemblies. Erco offers you two major advantages as an electronic and mechanical subcontractor — advanced engineering experience and talent that has solved thousands of assembly problems and — one-quarter million square feet of manufacturing facilities concentrated under one roof.

Send Erco an outline of your problems in these fields or write today Dept. MS, Riverdale, Md., for more details. They are given in the brochure "Erco — Production Facilities."

*Erco also built the trailer.

NUCLEAR PRODUCTS

ERCO

DIVISION, ACF INDUSTRIES, INC.

RIVERDALE, MARYLAND

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glossarifery

As in other arts and sciences, the field of instrumentation and automation, in growing, has developed its own vocabulary. As a public service, and in an effort to promote communication with the outside world, we set forth below definitions of the most commonly used terms.

AIRFRAME: Ambiguous terminology. May mean either a frame constructed around a body of air, or a body of air surrounding something.

ALCLAD: Entirely clothed.

BASE METAL: A term used by makers of aluminum products in referring to stainless steel and vice versa.

BLUEPRINT: A melancholy reproduction.

BREEDER REACTOR: Two rabbits of opposite sex.

BINDING ENERGY: Energy required to tie up a package.

CHAIN REACTION: Longitudinal waves in a light chain when one end is vibrated.

CHAPERONE: Force action on a couple to maintain it in a state of equilibrium.

CHARACTERISTIC CURVES: Easiest way to distinguish between a steward and a stewardess.

CHIEF ENGINEER: A person totally devoid of all engineering knowledge who married the boss' daughter.

CLOUD CHAMBER: A bedroom with clouds.

COSMIC RAY: A ray of powder, rouge and lipstick.

CYCLOTRON: Electron on a bicycle.

ELECTRON: A man up for election.

ENGINEER: One who is educated in the art of developing new and different ways of making the same mistakes.

FAHRENHEIT: A system of measuring vertical height above the earth's surface. One Fahren equals 0.53959 nautical miles.

FISSION: Drowning worms on the end of a stick.

FITTING FACTOR: A process used in structural analysis whereby a factor is manipulated so as to fit a particular requirement.

FRESHMAN ENGINEER: A young man who knows why a strapless gown is held up but doesn't yet know how.

HYDROGEN: An alcoholic beverage consisting of water and gin.

ISOTOPE: Ski area covered with ice.

K-ELECTRON CAPTURE: Russian electron in captivity.

MESON: My son (colloquial).
NUCLEI: A recent lie.
OHMETER: One who eats ohms.
OXIDE: The hide of an ox.
PILE: Big heap.
PHOTON: A man who takes pictures.
PLANCK'S CONSTANT: The amount lumber is reduced from given dimensions when purchased at a sawmill.
POSITION: A man who is always right.
QUANTUM: A large sum of Wamptum.
RADIATION: Johnnie Ray's cousin.
REACTOR: An actor who takes part when an old play is produced.
REYNOLD'S NUMBER: 92-71941.
RADIOACTIVITY: A function with the use of a radio.
ROENTGEN UNIT: Unit price of a gun when rented.
SLIDE RULE: A baseball regulation.
TELEVISION: An improvement over radio. Now you cannot only hear static, you can see it, too.
THEORY OF RELATIVITY: A scheme for getting rid of your mother-in-law.
WOMEN'S TEARS: The first successful fluid drive.

Reprinted from ISA (Cleveland Section) Bulletin, Vol. 8, No. 1, Sept. 57.

RELIABILITY DEPARTMENT HEAD

To assume responsibility of organizing and establishing a department which will conduct reliability evaluation studies of advanced liquid propulsion systems.

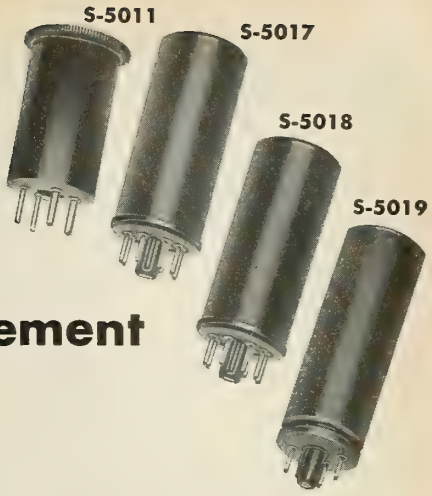
Previous rocket experience desirable but not necessary. Should have thorough grounding in techniques of reliability analysis coupled with supervisory ability.

Located near Sacramento, California, the area offers a combination of excellent climate and recreational facilities.

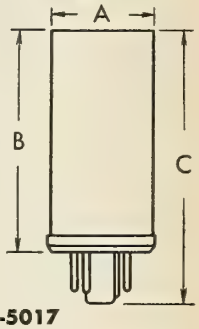
Send Resume To
H. RALPH TODD, JR.
Director, Scientific & Engineering Placement

AEROJET-GENERAL CORPORATION
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Full Wave SILICON Tube Replacement RECTIFIERS



Where dependability and ruggedness are a "must," Full Wave Silicon Tube Replacement Rectifiers will solve your problems. One of the four standard types described below will meet the requirements of your application.



S-5011
1N1150

Maximum Rating:
Peak Inverse Voltage per Section ..... 1600 Volts Max.
Peak Rectifier Current per Section ..... 8000 MA Max.
DC Output Current ..... 750 MA Max.
Ambient Temperature ..... 100°C Max.

Dimensions:
A—1-1/2" O.D. B—2-1/4" C—2-27/32"
Four Pin Base
Replacement for Types 80, 82, 83, 83V, 5Z3

S-5017
1N1237

Maximum Rating:
Peak Inverse Voltage per Section ..... 1600 Volts Max.
Peak Rectifier Current per Section ..... 8000 MA Max.
DC Output Current ..... 750 MA Max.
Ambient Temperature ..... 100°C Max.

Dimensions:
A—1-3/16" O.D. B—2-19/32" C—3-5/32"
Octal base
Replacement for Types 0Z4, 5X4, 5Y4, 6AX5, 6X5

S-5018
1N1238

Maximum Ratings:
Peak Inverse Voltage per Section ..... 1600 Volts Max.
Peak Rectifier Current per Section ..... 8000 MA Max.
DC Output Current ..... 750 MA Max.
Ambient Temperature ..... 100°C Max.

Dimensions:
A—1-3/16" O.D. B—2-19/32" C—3-5/32"
Octal base
Replacement for Types 5AU4, 5AW4, 5AZ4, 5T4, 5U4, 5V4, 5W4, 5Y3, 5Z4

S-5019
1N1239

Maximum Ratings:
Peak Inverse Voltage per Section ..... 2800 Volts Max.
Peak Rectifier Current per Section ..... 5000 MA Max.
DC Output Current ..... 500 MA Max.
Ambient Temperature ..... 100°C Max.

Dimensions:
A—1-5/16" O.D. B—3-3/4" C—4-5/16"
Octal Base
Replacement for Type 5R4

Send for data sheets on any of the above types.

Sarkes Tarzian, INC. **RECTIFIER DIVISION**

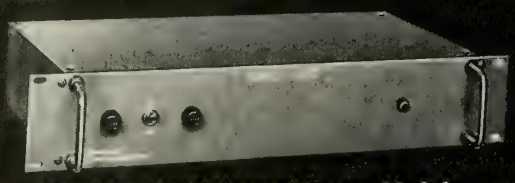
DEPT. RS-4, 415 NORTH COLLEGE AVE., BLOOMINGTON, INDIANA

IN CANADA: 700 WESTON RD., TORONTO 9, TEL. ROGERS 2-7535
EXPORT: AD AURIEMA, INC., NEW YORK CITY

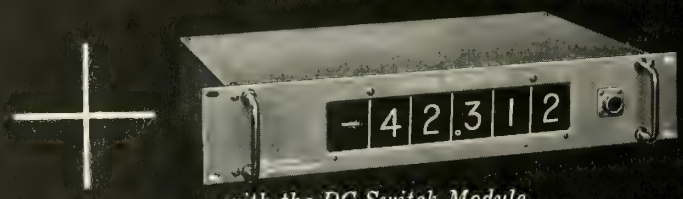
Circle No. 95 on Subscriber Service Card.

Precision instruments for automatically measuring DC, AC-DC, Ohms and DC-AC ratios constructed from basic modules.

For example:

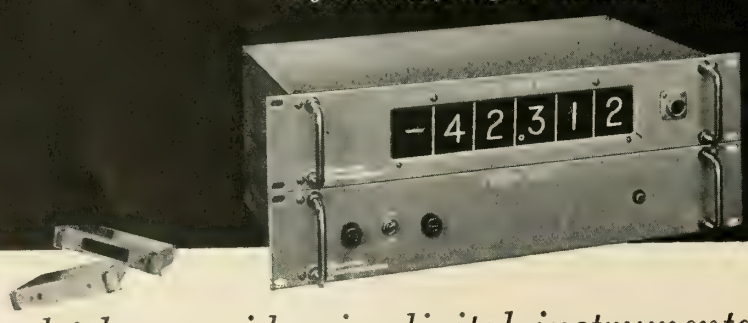


Combine the Universal Power Module



with the DC Switch Module

to get an 0.01% Digital Voltmeter



a completely new idea in digital instrumentation!



Now from five basic E-I modules, almost any combination of instruments can be assembled for precision, digital measurement of DC, AC-DC, Ohms and AC-DC Ratios. The basic E-I modules never become obsolete. As needs change, simply regroup or add new modules. This new modular concept provides maximum versatility and enables equipment to be kept current at minimum cost and engineering.

New engineering specification and other features have been incorporated into the basic modules from the experience of over 2,500 digital instruments in the field. Where applicable, all circuits have been fully transistorized to provide increased reliability, low power consumption, low heat dissipation and to eliminate radio noise and line transients.

New catalog sheets *give the complete story of this newest advance in digital instrumentation and complete specifications on all modules. Write for your set today.*

ELECTRO INSTRUMENTS INC. 3794 Rosecrans, San Diego, California

Circle No. 96 on Subscriber Service Card.

NEW MISSILE PRODUCTS

MINIATURE PUMP CARTRIDGE

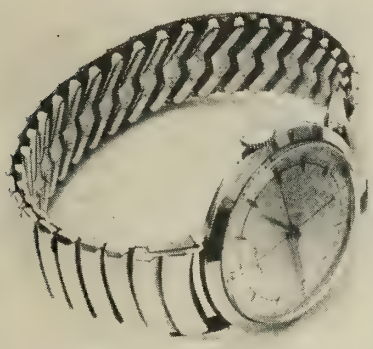
Miniature vane pump cartridges with a delivery capacity of 1.04 gpm at 1000 psi and 10,000 rpm are in production at Vickers, Inc. The unit weighs 2.5 oz. and has an output of 0.6 hp. Overall diameter is slightly less than 1 1/8".

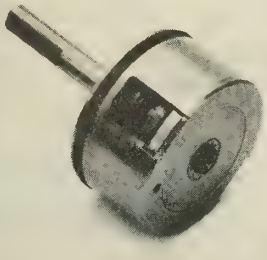
The pump may be supplied separately for incorporation into the user's housing either singly or stacked on a common shaft, or the manufacturer will furnish suitable housings. It can be manifolded with servo valves, miniature piston hydraulic motors and FHP electric motors.

The cartridge features hydraulic balance to eliminate pressure-induced bearing loads and the company feels that the performance figures currently cited will be extended. Shown with the cartridge is a standard wrist watch for comparison of size.

A minimum change in performance during the pump's life is expected by the company because optimum running clearances are automatically maintained by vanes and pressure plates that are self-compensating for wear. The cartridge incorporates many desirable features of the firm's larger models and overall construction is somewhat similar.

The unit is applicable for such operations as small radar or computer drives, electronic cooling, fuel pumps, missile skin cooling, flow dividers or pressure lubrication.



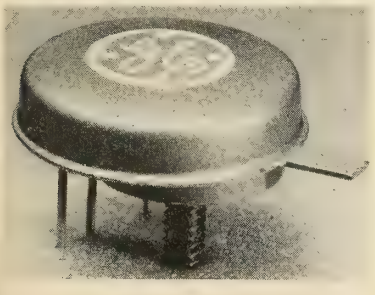


Circle No. 212 on Subscriber Service Card.

SILICON POWER TRANSISTOR

General Electric Co. has produced an 85-watt silicon power transistor said to have the highest power rating of any high-temperature transistor in the industry. The device will dissipate 85-watts at 25°C mounting base temperature and has a nominal collector saturation resistance of 2 ohms.

The component, designated the 2N-451, is produced by the vapor-diffusion process and is hermetically sealed in an all-welded case designed for mounting on an external heat sink.

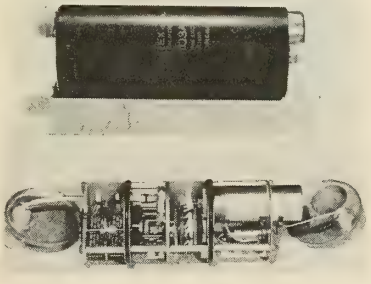


Circle No. 210 on Subscriber Service Card.

BINARY TIME CODE GENERATOR

Giannini DATEX Model DC-103 produces a serial output of one synchronizing pulse followed by eight bits of binary coded DC timing signals per second. Total number of signals is 128.

Shock mounted, the unit withstands temperatures from —65°F to 170°F; linear acceleration of 75g along major axis; shock of 30g on any axis and vibration of 15g. It is completely enclosed in a hermetically sealed container and electrical connections are made through hermetically sealed plugs.



Circle No. 205 on Subscriber Service Card.

MIRROR GALVANOMETER

Hilger & Watts Ltd., of England, is producing a self-contained mirror galvanometer offering sensitivity as high as 2000 millimeters per microampere. The Hilger "Galvoscale," being handled in this country by Jarrell-Ash Co., features a brightly lit, built-in scale, fully legible under ordinary room illumination.

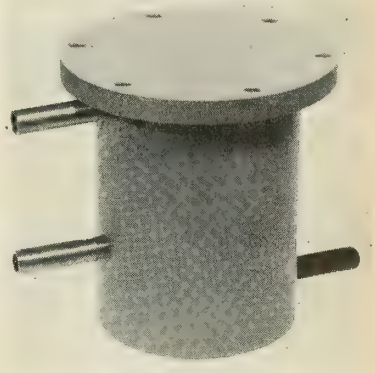
The magnified scale image moves below a stationary index line within a viewing hood and eliminates the visual effort, as well as the darkened room, required by other types of mirror galvanometer employing a traveling light spot and a stationary scale.

The instrument occupies table space of 12" x 21", but its scale length is equivalent to an optical lever nearly seven feet long. Both linear and logarithmic scales are available. Built-in shockproofing eliminates the need for special mountings.

Circle No. 209 on Subscriber Service Card.

ULTRASONIC TRANSDUCER

A high-efficiency ultrasonic transducer incorporating the most recent developments in magnetostriction transducer design has been developed by Massa Laboratories. The new device is said to be virtually indestructible and can operate continuously with 400 watts of power input with a conversion efficiency of 40%.



A sound pressure of 1 million dynes/cm² results in the vicinity of the transducer when radiating into open water with 100 electrical watts input to the structure. Cavitation is evident at this power level throughout about 80° total angle.

The polished stainless steel diaphragm has a radiating face 2 3/4" in diameter. Specifications: operating frequency—26 kc; impedance—150+j100 ohms; over-all dimensions—4 3/8" dia. x 4 7/8" long (6-ft. waterproof cable attached); water cooled, 5 gph for 30°F rise at 400 watts continuous input power; weight 6 lbs.

Circle No. 206 on Subscriber Service Card.

TELEMETERING SWITCH

A multichannel sampling switch designed for telemetering at altitudes up to 200,000 feet and at temperature from 125°C to —65°C has been developed by Applied Science Corp. of Princeton. It is available with from one to five



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poles and with up to 60 contacts per pole at sampling speeds ranging from 0.5 to 30 RPS.

Various motor drives are offered and the speed regulation is ±3%. The switch withstands shocks of 150G bi-directional, 100G continuous acceleration bi-directional and a vibration of from 20 to 2000 cycles at 20G for ½ hour.

Circle No. 208 on Subscriber Service Card.

SUBMINIATURE COMPONENTS

New subminiature fixed glass capacitors are currently being produced by Corning Glass Works. Termed Corning WL capacitors, the radial lead units are being designed for printed circuit boards. Production is expected to begin in the near future.

No clamps are required because the high temperature soldered leads allow the capacitor to be connected directly to the breadboard. Both types of the component measure less than 0.1" thick, making them well suited for vertical mounting in small, high-rated circuits.

The units have a fixed temperature coefficient, high insulation resistance, low dielectric absorption and ability to operate under high humidity and temperature conditions. The capacitors are rated at full voltage at 85°C, and withstand temperatures up to 250°C for short time loads of low voltage applications.

Circle No. 200 on Subscriber Service Card

PRECISION RESISTORS

Epoxy-encapsulated wire-wound precision resistors, vacuum impregnated and vacuum cast to eliminate hot spots have been developed by Kelvin Electric Co. The series EP resistors utilize tension-free winding techniques which reduce resistance drift with age, and shorts or opens due to thermal shock. The operating range is from —65° to 125°C and temperature coefficient is ±.000020°C.

Two types are produced in the series. 3/16" in diameter x 3/8" long and 1/4" diameter x ½" long. Other types are available to handle up to two watts dissipation.

Circle No. 203 on Subscriber Service Card.

ATOMIC FREQUENCY STANDARD

The development of the Atomichron by National Co. has produced a frequency-producing instrument providing frequency stability of 5 parts on 10^{10} and frequency accuracy of 1 part on 10^{9}.

The instrument uses the atomic principle of frequency control by comparing the precise resonance of the atoms of cesium with the output of a crystal oscillator to obtain stability said to surpass any frequency generator in existence. The unit is also self-monitoring and requires minimum adjustment and maintenance.

Circle No. .218 on Subscriber Service Card.

PLUG VALVES

Circle Seal Products Co. has announced new sizes available in their line of plug valves. The valves feature deadtight shut-off and external leakage prevention through the use of "O" rings. In the open position, the valve is full-ported and allows straight-flow passage. Valves are available in pipe sizes ¼", ½", and ¾" in brass. The ¼" size is also available in stainless steel with an aluminum handle.

Circle No. 216 on Subscriber Service Card.

PORTABLE FORCE CALIBRATOR

This portable unit is designed for calibrating existing weight, force and thrust measuring systems and has direct reading, automatic balance and digital servo indicator features. Produced by Gilmore Industries, Inc., the model 170 is said to provide 0.1% accuracy of reading or 0.1% of lowest range, whichever is greater. National Bureau of Standards calibration can be supplied by the manufacturer.

The model 170 uses a continuous balance servo system in a portable case and the indicator is calibrated with a precision strain gage load cell for tension or compression measurements. The instrument requires no batteries or standardization circuit. Provision is made for range suppression to increase the resolution and accuracy of the system. The complete unit is 6 9/16" wide x 13½" high x 16" deep.

Circle No. 211 on Subscriber Service Card.

PACKING GLAND

Conax Corp. is introducing its micro packing gland measuring 21/32" long and 11/32" hex. The new gland may be used to seal tubes of any material because the soft sealant makes it indifferent to tube composition. Increased fatigue strength and resistance to vibration are assured by reduction of stress concentration at the point of seal.

Temperature ranges of the gland with teflon sealant are —90°F to 500°F and seal pressures from 0.005 microns up to 1000 psi. Using lava sealant, temperatures range from —300°F to 1850°F with pressures from 0.005 microns up to 3000 psi. Standard bore sizes of the glands are 1/16" and 3/32" with 1/16" IPS thread and non-standard bore sizes ranging from .030" to .096" available on request.

Circle No. 214 on Subscriber Service Card.

ALL-ELECTRONIC CHOPPER

An all-electronic chopper containing no moving parts and having a minimum operating life of 5000 hours is available from the Kearfott Co. The unit converts usable DC into AC and vice versa.

Primary features include a zero phase shift, 180° dwell time, frequency range of 60 cps to 20 kc and an unlimited life when properly applied. Reference power is 6.3 V at 2 ma; load resistance is 1000 ohms to 1 megohm; load current 5 ma maximum; balance is —0°; and the ambient temperature range is —55°C to 125°C with no measurable output drift.

Circle No. 204 on Subscriber Service Card.

HIGH-TEMPERATURE ADHESIVE

The first successful adhesive system for stainless steel metal-to-metal bonds and honeycomb sandwich constructions capable of withstanding continuous exposure to temperatures up to 500°F have been developed by the Rubber and Asbestos Corp.

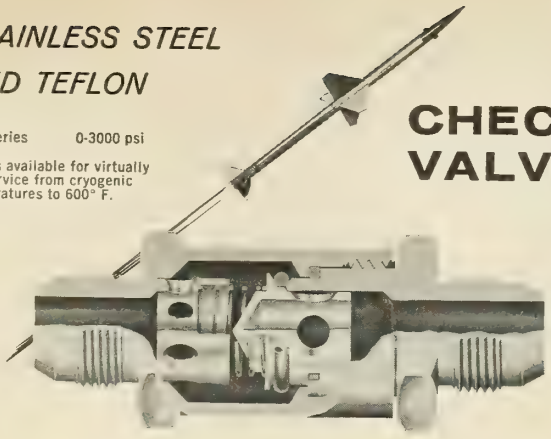
For stainless steel metal-to-metal bonds, the company produces Plymaster 1020, a tape of nominal 20-mil thickness. Testing the adhesive on type 302 stainless, 1" x 4" with a ½" overlap (steel thickness 0.050"), R & A Corp. established the following values: lap shear strengths of 1750 psi at room temperature; 1500 psi at 455°F after ten-minute soak; 1400 psi after conditioning 200 hours at 455°F and tested at that temperature; 800 psi after conditioning 400 hours at 455°F and

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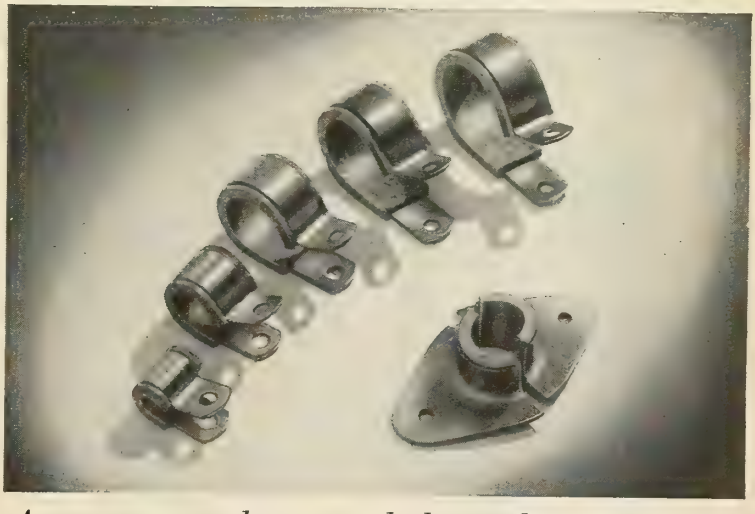
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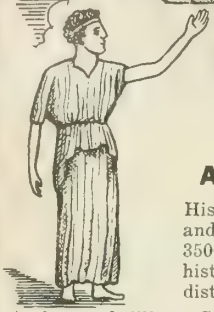
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FLIGHT TEST 400 BC

Archytas and his wooden pigeon

Historians and archeologists have recorded legends and mythology dealing with flight as far back as 3500 B.C. However, it is not until 400 B.C. that history records the first actual flight experiment distinctly removed from pure mythology.

Archytas, brilliant Greek philosopher, scientist, mathematician and general, is credited with constructing a wooden, self-powered flying dove. While this historic episode has been discussed and investigated for twenty centuries, a logical scientific explanation is still lacking. Theories offered to explain the alleged flight have been many—a lighter-than-air wood unknown to us today, the use of a gas within the model, and even a mechanical device which may have been the forerunner of combustion engines. Most researchers think of Archytas' accomplishment as "possible but incredible."

Aeronautical Testing, 1957 A.D.

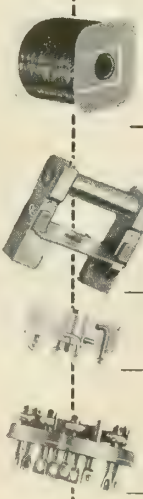
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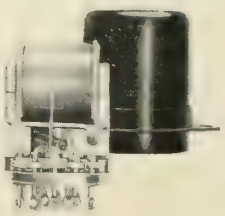
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tested at that temperature; and proportionate ranges after testing at 500°F.

The new adhesives for stainless steel honeycomb sandwich construction are a one-part primer, trade-named Bondmaster M605, and Plymaster 2040, a tape of nominal 40-mil thickness which is used with the primer.

Test data on the latter adhesives on 0.003" type 321 stainless steel honeycomb core, 1/4" cell size, with facing skins of type 302 stainless steel, 0.025" thick, show beam flexural strengths up to 1500 lbs. on unconditioned sandwiches tested at 455° F. 10 minute soak; up to 1400 lbs. after conditioning 200 hours at 455°F and tested at the same temperature; and up to 1400 lbs., unconditioned, tested at 500°F, 10 minute soak.

All three of the new products are based on modified epoxide resins.

Circle No. 207 on Subscriber Service Card.

INTEGRATING RATE GYRO

A light-weight integrating rate gyro with self-contained temperature control has been designed by General Electric. The gyro's temperature control operates on the heat-of-fusion principle and is designed to maintain a temperature of 80°C with a tolerance of 1/3 degree or it can be altered to maintain other temperatures with the same low tolerance.

The complete unit, designated the KR-8, is 3" long, 2" in diameter and weighs only 1¼ lbs. It has shown a maximum wander of 6/10 degree for a period of more than four hours. The device's minimum life is 1000 hours.

Circle No. 202 on Subscriber Service Card.

SERVO-AMPLIFIER

A miniaturized, transistorized servo-amplifier for missiles application has been designed and is in production by Kearfott Co. The small, lightweight unit delivers a maximum power of 6 watts, is shock and vibration resistant and is a plug-in type component. Signal frequency is 400 CPS ± 20 CPS and the maximum signal input voltage is 30 volts. The unit's gain stability is rated at ±3db (—55°C to 71°C) and the entire device is completely potted.

Circle No. 215 on Subscriber Service Card.

MOTOR-TACH GENERATOR

A high temperature miniature motor-tach generator with low output to null ratio has been developed by John Oster Manufacturing Co. Type 10-MTG-6229-15 operates continuously in an ambient temperature range from —55°C to 125°C. Length is 2.131", null voltage .012, linearity 5% to 4,000 rpm, output voltage .3 per 1,000 rpm and excitation 18 v 400 cycles. Variations of voltage and shaft can be furnished to specification.

Circle No. 219 on Subscriber Service Card.

SILICON RECTIFIER STACKS

A new series of 170°C silicon rectifier stacks has been added to GE's line of semiconductor rectifiers. The units are rated up to 18 amperes per stack, and stacks may be paralleled for even higher currents. The standard stack is available with RMS input voltage ratings up to 3360 volts, and this may be increased by connecting in series. Operating temperatures range from —65°C to 170°C, with a maximum storage rating of 175°C.

Circle No. 217 on Subscriber Service Card.

people

Dean A. Harvey has been named director of contracts administration for the Associated Missile Products Corp.

Arthur H. Jones has joined Avco Mfg. Corp. as vice president, defense planning. He formerly was gen. mgr. of Motorola's military electronics center.

Norman L. Winter has been named manager of Sperry's Countermeasures group.

Dr. Charles H. Lutz has joined Hamilton Standard electronics department as chief of advanced design. **Dr. Lutz** was formerly with Arma Division of American Bosch Arma Corp.

Roy E. Wendahl, Hughes Aircraft Co. vice president and gen. mgr. of Tucson operations, has been named to the newly created post of vice president of sales. He will make his offices at the company's Culver City executive offices.

Wallace G. Wade has been appointed head of the Janco laboratory. He was previously with the standards laboratory of the Los Angeles department of Water and Power.

Dr. Raymond L. Garman has been elected to the post of chairman of the board of General Precision Laboratory, Inc. He will continue as technical director in charge of research and development. **James W. Murray** was elected president and chief executive officer, continuing as general manager.

Chester C. Utz has been named executive engineer of Chrysler Corp.'s defense operations division.

Lieut. Gen. Patrick W. Timberlake, (USAF, Ret'd) has been elected corporate vice president of Northrop Aircraft, Inc. He previously was commander of allied air forces in southern Europe.

Gladyn H. Putt has been named executive assistant to **L. Eugene Root,** vice president of Lockheed Aircraft Corp. and general manager of its missile systems division.

Philip D. Terry has joined Western Gear Corp. as regional marketing mgr. of aircraft & missile products for the eastern states.

G. J. Rauschenbach has been named director of sales for the Martin Co., moving from the company's Baltimore division to the Denver Division. He formerly was assigned sales management duties on all advanced design missile projects at the Baltimore facility.



HARVEY



JONES

Geoffrey Parsons, Jr., former director of information for NATO, has been elected vice president for Europe of Northrop International.

Dexter Rosen has been appointed administration department manager for Bell Aircraft Corp.'s guided missiles div.

James W. Walker has been named to handle Rocketdyne's export programs, formerly handled by North American Aviation's corporate export office.

Martin Boe, of North American Aviation, Inc., has been appointed to the post of air-to-surface missile engineering manager and **Sanford Falbaum** has been named ASM asst. engineering manager for the company. North American has also appointed **Dale D. Myers** project manager on the AF long range bombardment ASM development program.

Dr. Ernst A. Steinhoff will direct the Air Force missiles department at Aerophysics Development Corp. Since 1950, he has been technical director of Holloman air development center.

Dr. Thomas H. Johnson, Atomic Energy Commission research director, has been appointed manager of Raytheon Mfg. Co. research division. He resigned from the AEC, effective October 1.

Cornell Aeronautical Laboratory, Inc. has been reorganized into six new divisions. Division heads are: **William F. Milliken,** full scale division; **Dr. Franklin K. Moore,** aerodynamic division; **Harold A. Cheilek,** engineering sciences division; **Robert H. Shatz,** systems research division; **Robert S. Kelso,** experimental facilities division; and **Dr. Seville Chapman,** physics division.

Brig. Gen. Robert E. Galer (USMC, Ret'd), former director of the guided missiles division of the Navy's Bureau of Aeronautics, has joined Temco Aircraft Corp. as mgr. of engineering programs.

John P. Broderick has joined the applications engineering department of Yardney Electric Corp.

Capt. Otis R. Hill has been appointed USAF Development Field Representative for a new San Francisco Bay area ARDC office.

Richard Driskell has been named engineering production manager of Humphrey Inc., directing control of the company's production of rate and free gyros, linear and angular accelerometers and other control instruments.

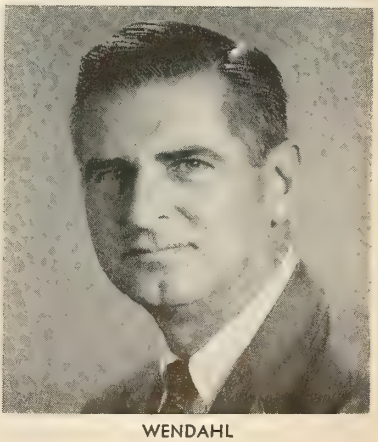
Four research managers have been named by the Government and Industrial division of Philco Corp. New managers and their phase of work are: **J. Forrest Bigelow,** radar and radio systems; **F. J. Bingely,** audio-video data systems; **C. P. Woodward,** missiles and advanced tactical systems, and **Ralph Deutsch,** fundamental



WINTER



LUTZ



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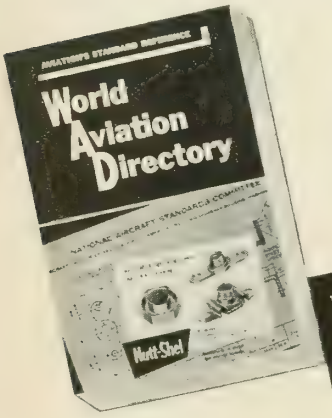
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techniques. All previously with Philco.

Bernard B. Daien has been appointed chief engineer at Transistor Devices, Inc.

Josiah E. Smith, aerodynamicist, has joined the guided missile research division of Ramo-Woolridge Corp. in Los Angeles.

Dr. J. Howard Brown, Morton S. Kircher, and **Dr. Jack S. Newcomer** have been named as research managers in Hooker Electrochemical Co.'s realignment of its R & D staff.

Dr. James T. Grey, Jr. has been named scientific advisor to the Air Force's Directorate of Research and Development. Grey is head of the chemistry section of Cornell Aeronautical Laboratory, Inc., and will be on leave of absence while carrying out the new assignment.

Col. Arnold T. Johnson has been designated deputy commander of the ARDC's Arnold Engineering Development Center at Tullahoma, Tenn. Prior to assignment to AEDC, Johnson was chief of the USAF section, Military Assistance Advisory Group, Saigon, Viet-Nam. The AEDC is the wind tunnel test center for the Air Force.

Robert G. Schmidt has been appointed project manager for the new $4-million plant of Callery Chemical Co. at Lawrence, Kansas. **Stanley J. Demski** is newly appointed construction manager for the plant, which will produce boron specialty chemicals.

Arthur J. Warner of Harlow, Essex, England, has been named director of research for Mycalex Corp. and associated companies. He will assume responsibility for materials and product development in the field of electronic components, glass-bonded mica, ceramoplastic insulation and synthetic mica.

Edward Rubin has been appointed assistant to the president of Wyle Laboratories, El Segundo, Calif., qualification and testing organization. He was previously manager of powerplant administration at Marquardt Aircraft Co.

Abraham Fuchs has been named head of the analytical department of CDC Control Services, Inc., producers of high-performance servo-mechanisms.

Richard W. Griffiths has been appointed director of sales for the components division of Litton Industries.

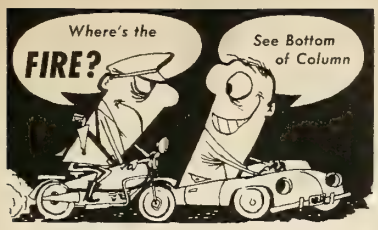
Dr. Arthur C. Ruge has been named director of research development of the electronics and instrumentation division, Baldwin-Lima-Hamilton Corp. Working under Ruge will be **Robert P. Lathrop,** newly-appointed manager of research and development for the division.

Harry McPherson has been chosen to head Temco Aircraft Corp.'s testing program for its missile weapons system. McPherson was previously technical design test coordinator for Convair in Fort Worth.

Sterling C. Spielman has been appointed director of engineering for Philco's Government and Industrial division, assuming full responsibility for all design and development activities. He will be assisted by **Frank D. Peltier,** named director for engineering planning.

Leonard Brewer has been assigned as project director for rocket engines in the solid propellant R & D department. Brewer was formerly with Thiokol Chemical Corp. in Huntsville, Ala.

Col. Carl W. Armbrust has been named executive officer in the Directorate of Procurement and Production, Air Materiel Command. Armbrust formerly served as chief of the airframe, missiles and engine section of AMC's Industrial Resources division.



Dr. Bernard Greifer has joined Atlantic Research Corp. as a member of the kinetics and combustion group. He was formerly with the U. S. Bureau of Mines. At Atlantic, he will conduct research in gaseous and solid combustion processes.

Col. Paul F. Nay, former director of aeronautics at ARDC headquarters, has been assigned to ARDC's field office in Los Angeles.

Lionel H. Orpin has been named director of plans and programs of Stromberg-Carlson division of General Dynamics Corp. He was formerly with the Convair division.

Dr. Oskar Mattiat has joined the Aerophysics Development Corp.'s engineering staff. He formerly was head of the special devices group at the Clevity Research Center in Cleveland, and also directed the electric wave filter section. Aerophysics also appointed **Dr. Robert B. Costello** as assistant manager of the materials department. He previously served as project engineer for Corning Glass Works.

J. F. Harrigan has been named manager of the Dayton liaison office jointly maintained by Reaction Motors, Inc. and Olin Mathieson Chemical Corp. He will be responsible for representing the two companies with the Air Force and area contractors. Before his appointment, he was with Lear, Inc. as contracts manager.

Dr. Lloyd H. Wilson has been appointed manager of the reentry body department of the Missile Systems Division of Lockheed Aircraft Corp. Also named as a manager was **Dr. Wayland C. Griffith,** of the flight sciences division in the research and development branch.

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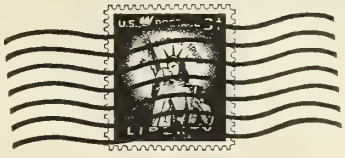
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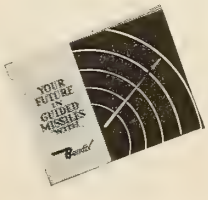
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NEW PRODUCT BRIEFS

OXY ADHESIVES. When cooled to 0°F, epoxy synthetic glue holds some ht metals together with enough ength to withstand a force of 8000 . psi. The synthetic adhesive does not come brittle with sudden and ex- me changes in temperature and in- eases in strength as the temperature ops. National Bureau of Standards.
cle No. 251 on Subscriber Service Card.

OXY-SATURATED INSULATION. Two w types of epoxy-saturated electrical ulation for class B applications are ailable. The asbestos-base products said to have unique electrical and rmal properties. The material is avail- le in rolls, tape or sheet form. Johns- anville Corp.
cle No. 252 on Subscriber Service Card.

XIDE SCALE REMOVER. A process removing oxide scale from titanium s been developed by Temco Aircraft rp. The electrolytic process removes scale without the use of acids or nd labor.
cle No. 253 on Subscriber Service Card.

LICONE RESIN. This material for nding low-pressure structural laminates parts to glass cloth the qualities us- ly associated with polyesters. It was veloped for the vacuum-molding of mplex structural parts, provides high ength at elevated temperatures, has dielectric losses and is available in mmercial quantities. Dow Corning rp.
cle No. 254 on Subscriber Service Card.

ANSISTORIZED CONVERTER. A nsistorized 30 amp constant conver- featuring current stabilization, selec- n of current levels in 50 ma steps m ½ to 30 amps, and numerous test- applications and other features have en developed by North Hills Electric . Inc.
le No. 255 on Subscriber Service Card.

ULTI-FUNCTIONAL INSTRUMENT. med "Voca," this instrument com- es a precision differential null type entiometric voltmeter and calibrator AC, DC and VTVM. Used for pro- tion line testing, calibration of mul- eters, vacuum tube voltmeters and illoscopes, circuit test and design other applications. Demolab Corp.
e No. 256 on Subscriber Service Card.

CISION TRIANGLES. Layout trian- of consistent precision, designed to lace metal triangles in many appli- ons, have been produced by the gorukov Mfg. Co.
e No. 260 on Subscriber Service Card.

TUBE CLAMPS. A line of "Kool Klamps" designed to provide adequate cooling and easy tube changing as well as to retain miniature tubes under extreme vibration and shock is available. The new clamp features an ejector pin to facilitate removing tubes in restricted chassis areas.
Circle No. 257 on Subscriber Service Card.

COAXIAL TERMINATORS. Stoddart Aircraft Radio Co. is producing a coaxial terminator of 9/16" diameter with precise resistance values from DC to 1000 mc. VSWR on the unit is less than 1.20 to 1000 mc, characteristic impedance is 50 ohms and the peak voltage is 100 volts. The component is available with either type BNC or TNC male or female connectors.
Circle No. 258 on Subscriber Service Card.

CONSUMABLE WELD INSERTS. Use of EB weld inserts permits welding from one side of metal and eliminates need for back-up rings in welding of tanks for missiles. Tensile strength of 200,000 psi is developed in the weld metal by heat treatment. Arcos Corp.
Circle No. 259 on Subscriber Service Card.

COAXIAL PUSH-BUTTON DISCONNECT. RF coaxial connectors with a built-in push button disconnect switch eliminate the necessity of removing the cable from an assembly. Available with type "N" and "HN" hermetically sealed receptacles. Don-Lan Electronics Co.
Circle No. 261 on Subscriber Service Card.

RESOLVER. High-accuracy and impedance size 15 resolver features tuned impedance of 10,000 ohms and accuracy of ±0.1% from —55°C to 85°C with amplifier. Norden-Ketay Corp.
Circle No. 262 on Subscriber Service Card.

PROXIMITY SWITCH. Manufactured to detect ferro-magnetic objects without coming in contact with the object. The unit has no moving parts and may be mounted on a surface extending only 3¼" from the material which operates it. Excitation is 100-125 V, 60 cps, 2 watts (nominal). Minneapolis-Honeywell.
Circle No. 263 on Subscriber Service Card.

RATIOMETER. Servonics, Inc., has introduced a new Unity Ratiometer featuring fast accurate readout, continuous balance, automatic polarity indicator and complete self-containment.

The device has unlimited application with DC analog computers and is equipped with an output shaft extension.
Circle No. 264 on Subscriber Service Card.

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MISSILE LITERATURE

TRANSISTOR MANUAL. The second edition of a transistor manual containing basic information on transistors and their use in electronic circuits has been published by GE. Included in the 112-page manual are data on semiconductor theory, construction techniques, explanation of symbols, specifications (with drawings) of all transistors currently registered with the Electronic Industries Association, and other pertinent data. General Electric Co.

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AERODYNAMICS RESEARCH. Three reports of aerodynamics research for USAF, two of them on wind tunnel tests and the third on ignition and combustion, have been released to industry. OTS, Dept. of Commerce.

Circle No. 151 on Subscriber Service Card.

TRANSITOR SERVO AMPLIFIER. Four-page brochure giving performance characteristics of miniaturized units. Covers models of the 60 and 400 cps TRAMPS. M. Ten Bosch, Inc.

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TIME-RATE INDICATOR. Applications of a 10 mc time-rate indicator for measuring frequency, counting pulses per unit time, measuring interval between pulses, and other similar operations are discussed in bulletin 501A-B, published by Laboratory for Electronics, Inc.

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COMPANY INFORMATION. Information on the various aviation divisions of Kelsey-Hayes Co. is listed in a 32-page booklet just released. Products and services available are listed in the free booklet. Kelsey-Hayes Co.

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PIEZOELECTRIC CRYSTALS. A revised edition of the Air Force's "Handbook of Piezoelectric Crystals for Radio Equipment Designers" has been released. Prepared as a guide for designers of military electronic devices, the manual contains a comprehensive examination of piezoelectric control of radio frequencies. It includes background material, circuit theory, components data and other information. The 702-page manual is sold for $7.00 through OTS, Dept. of Commerce.

Circle No. 155 on Subscriber Service Card.

OPTICAL TOOLING. The basic principles of optical tooling are described in a 56-page manual which includes photographs and drawings. Major instruments and accessories used in optical tooling are covered, and drawings show the optical principles used in applying the equipment. The application of optical principles permits tolerances as close as thousandths of an inch to be held at distances from a few inches to as much as a mile. Keuffel & Esser Co.

Circle No. 156 on Subscriber Service Card.

HYDRAULIC SYSTEM TESTER. A universal hydraulic accessories test machine is the subject of this brochure, which describes the machine's operations on valves, actuators, regulators, plumbing, tube and hose lines, manifolds, and other accessories. The machine simulates actual flight conditions and is said to test hydraulic components to the most rigid specifications. Greer Hydraulics, Inc.

Circle No. 157 on Subscriber Service Card.

CLOSED CIRCUIT TELEVISION. Indus trial closed circuit television systems and accessories are described in a catalog recently published. It contains data on remotely controlled pan-tilt, iris-focus and other camera accessories, specia "ruggedized" equipment for operation under adverse environmental condition of noise, heat, shock, and temperatur and humidity extremes. KIN TEL Divi sion, Cohu Electronics, Inc.

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MAGNETIC AMPLIFIERS. Two report of research for the Armed Forces o standard and two-core magnetic ampli fiers are available through OTS, De partment of Commerce.

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METALLURGY STUDIES. The impac properties of boron-treated steels ca be disrupted by titanium introduced i boron addition agents, according to on of two new reports now available to in dustry. The other deals with a revie of work on development of a substitut material for a cobalt-based alloy. OTS Department of Commerce.

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TRANSISTOR ANALYZER. Four-pag bulletin describes model BCT-300 tran sistor curve tracer and includes bloc diagram showing the variety and func tions of the unit, as well as specifica tions. Norden-Ketay.

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NEUTRON SHIELDING. A folder o boral for neutron shielding, showing th material's composition, uses and shield ing properties, is available fro Brooks & Perkins, Inc.

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ROCKET DESIGN. Discussion of theo and practical application of rocket e gine design are among subjects covere in a new issue of "Thiokol Facts," house organ. Other articles include se lant applications and test equipmen Thiokol Chemical Corp.

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METAL FASTENERS. An eight-pag guide for design and assembly socket-head cap screws has been pu lished, giving physical characteristic thread lengths, torque tension data a other information useful in efficient a plication of the fasteners. Strong, Ca lisle and Hammond.

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PLASTIC TUBULAR CAPACITOR. E gineering bulletin describing type B plastic tubular capacitor for printed c cuits has been published and is ava able from Pyramid Electric Co.

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RUBBER PRODUCTS. Illustrated catal showing facilities for manufacturing ru ber parts to customer order. Empha is placed on special molded rubb parts, silicone rubber parts, rubb bonded-to-metal parts and other de on rubber synthetics. Williams-Bowm Rubber Co.

Circle No. 167 on Subscriber Service Card

CERAMIC RESEARCH. A 20-page b chure picturing and describing their f cilities for exploratory and developm tal work in industrial ceramic techn ogy has been published by Gladdi McBean & Co.

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EXCLUSIVE: Russia's Moon Rocket Program

by Erik Bergaust

missiles and rockets

INCLUDING MISSILE ELECTRONICS

THE MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

NOVEMBER 1957



Target Team

The U.S. Army's ground-to-air missiles require realistic training targets with speed, altitude capability and radar reflectivity that closely approximate the same characteristics of an invading enemy aircraft. In matching these specifications, however, cost becomes a major consideration.

By air launching a rocket target from a drone at high altitude, the cost of development and operation decreases and the training program gains efficiency. From these critical requirements grew Radioplane's concept for the RP-77DL and RP-76A target team.

Radioplane's turboprop drone, the RP-77DL, is ground launched carrying the rocket-powered RP-76A target. Upon reaching scheduled altitude the RP-76A blasts off to complete its target mission. The RP-77DL then returns to launch site under radio control to be readied for another team launching. Both the launch drone and the rocket target are recoverable by parachute.

First in the field of producing remotely controlled aerial targets, Radioplane continues this vital production while developing economical aerial target systems for tomorrow's missile training programs.

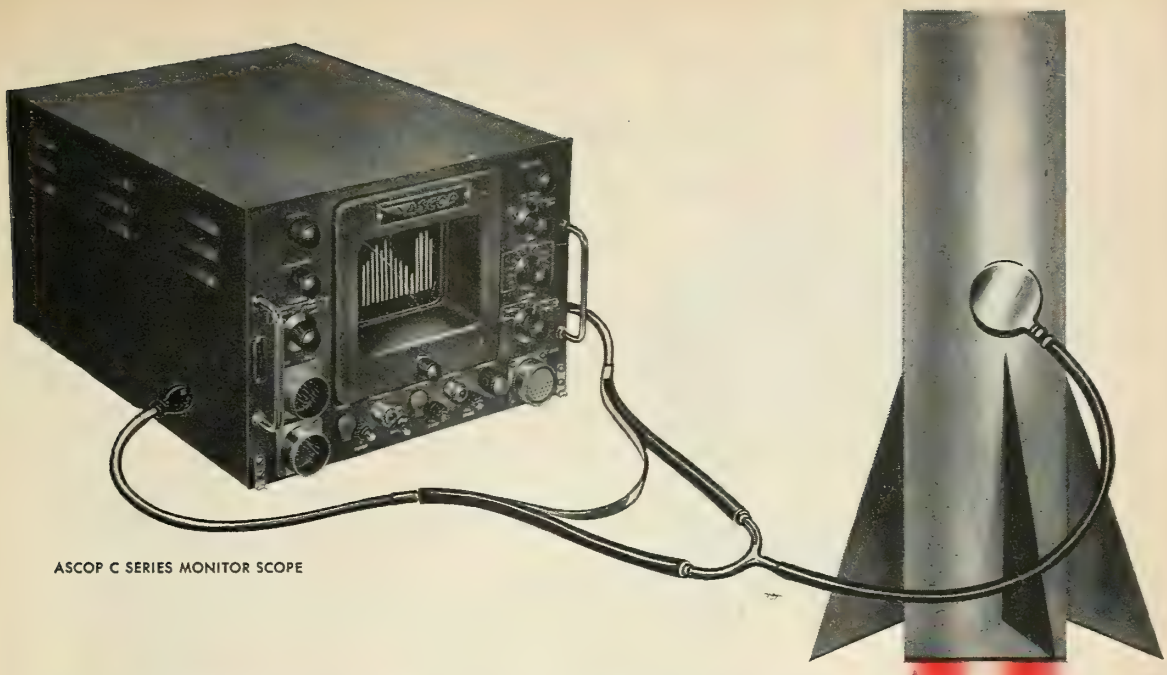
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The ASCOP Monitor Scope is a rugged unit for field or laboratory use designed to operate well under extremes of vibration, acceleration, noise and other difficult environmental conditions.

Our competent staff of sales engineers is available to aid you in your application of this equipment.



PRODUCTION LINE

Speeds up tests and reduces errors on the production line. Checks 14 units in rapid sequence by the flick of a switch. Provides a "quick look" at up to 86 variables at one time for each unit. Limits can be marked on the tube face with a grease pencil or crayon.



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The ASCOP Monitor Scope is portable . . . can be mounted on a mobile dolly or in a van and moved to a launching site to give a missile, rocket or aircraft a complete pre-flight check.



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Used in aircraft to provide the flight test engineer with vital data while a test flight is underway. Assures that data is being properly recorded in a magnetic tape data recording system. When used on the ground in conjunction with a radio telemetering system, provides complete in-flight missile monitoring.



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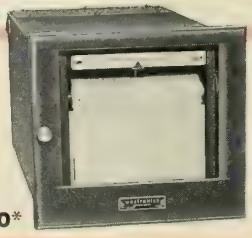
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Magazine of World Astronautics

November, 1957 Volume II, No. 11

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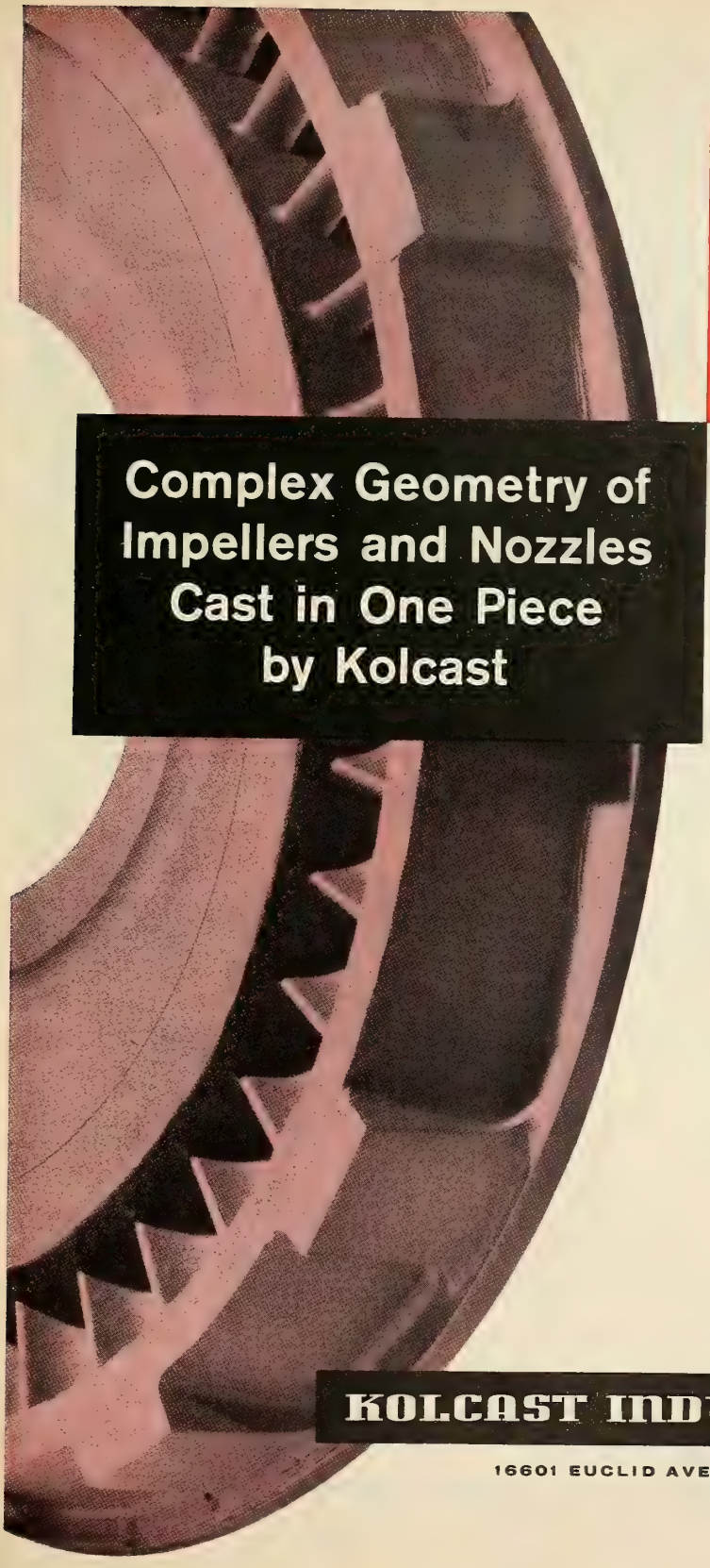
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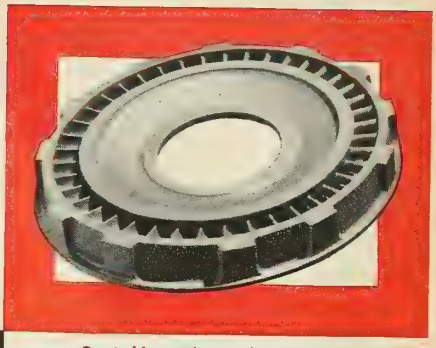
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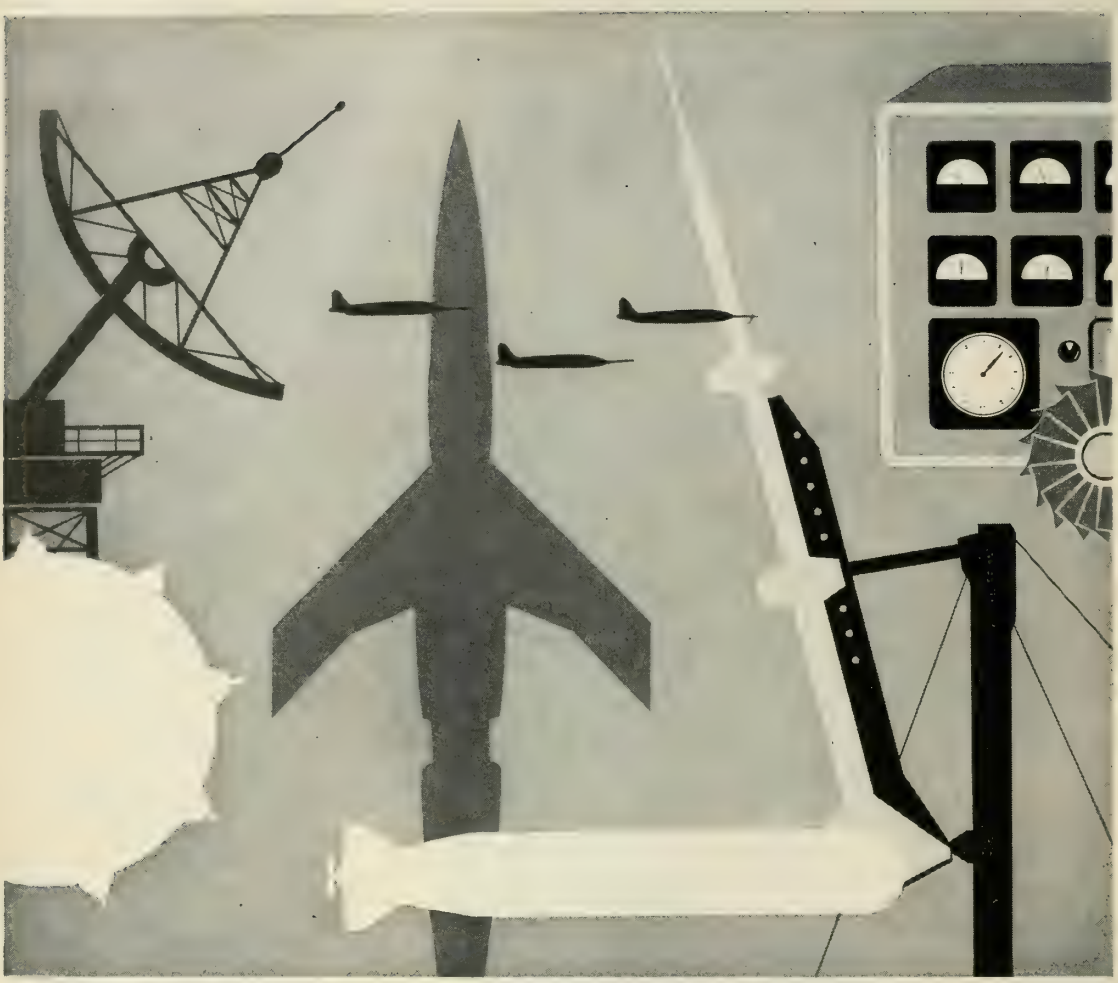
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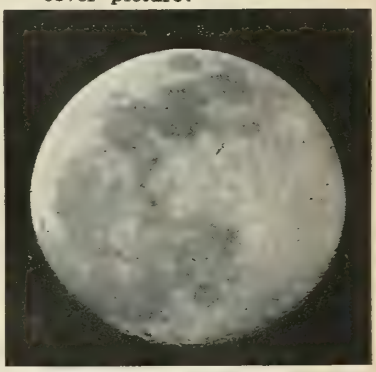
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cover picture:



The moon, as shown on our cover, has become vitally important. Man is just about to set foot on Luna. This is of such great concern as we have seldom known. With the race into space becoming more a matter of survival than just friendly competition, it is significant that we consider the most vital satellite of all—the moon. See the m/r *editorial on page 9 and our exclusive coverage of the Soviet moon rocket program, page 37.*

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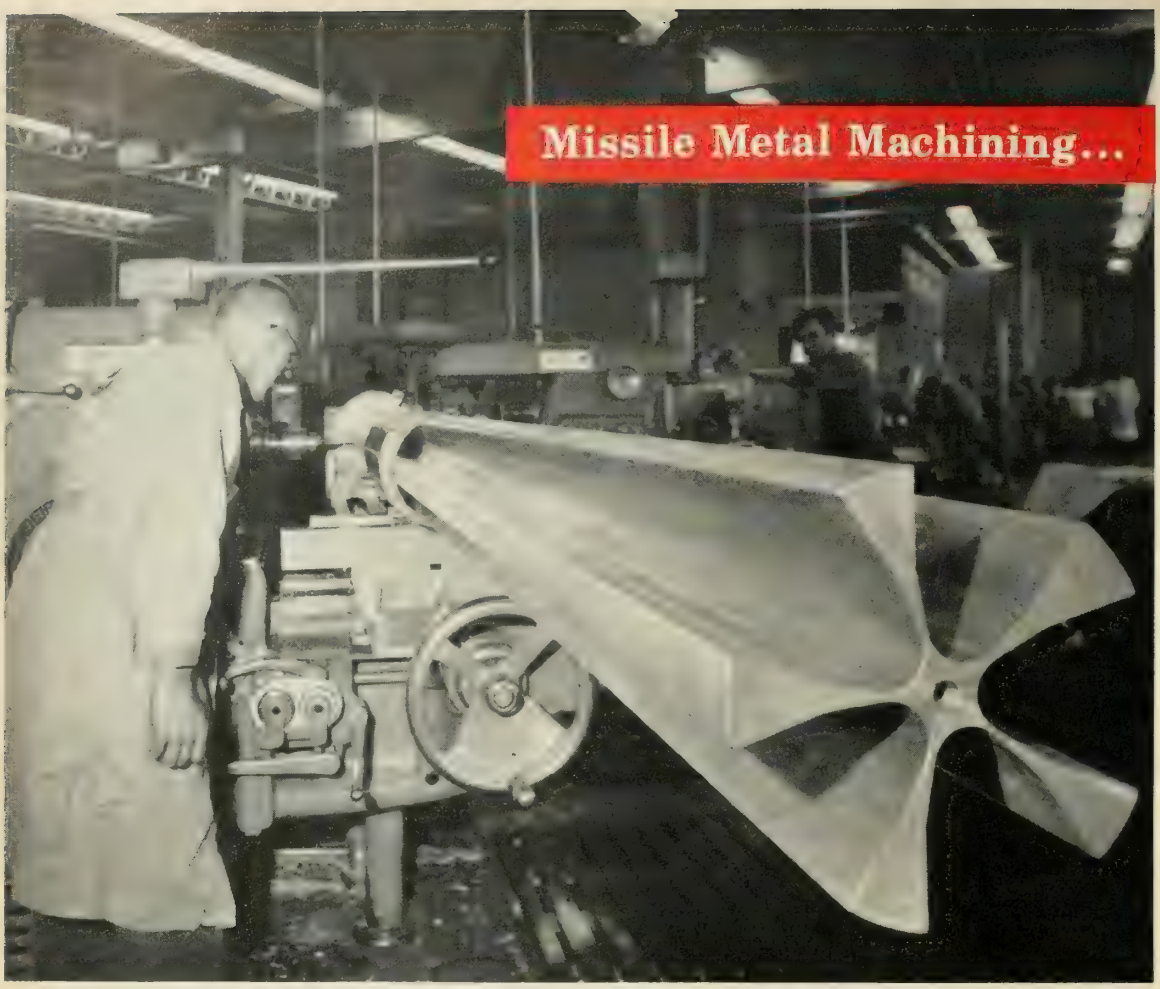
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An Open Letter to President Dwight D. Eisenhower

Mr. President:

This is the age of science. This is the era of intellectual, uninhibited thinking. Tomorrow is here. And you, as the leader of the greatest nation on earth, must see to it that this nation will be out in front as mankind advances into the space age.

Until recently many of your top-level officials have considered space flight trivial and irrelevant. Space travel was something for science fiction writers and comic strip authors. Even within the Air Force, officials and officers were not to mention or discuss space flight. Our government's top policy makers refused to heed the scientists and engineers who predicted many years ago that tomorrow's war would be fought with space weapons, and that the nation which controlled space would control world peace and the destiny of mankind. These top officials, we hope, soon will begin to see the light. Mr. President, you must lead the way.

Overnight the American people have learned that in spite of their material wealth, in spite of wrap-around windshield automobiles and chrome-plated washing machines, in spite of superhighways and supermarkets and our high standard of living—the world is questioning our leadership of world power.

We have been shown that the current World War III is a battle of the minds. The nation that demonstrates its technical superiority effectively and dramatically to the rest of the world will profoundly influence the minds of men. The American public is beginning to understand this. The extent that our government policy makers understand it can determine our destiny.

In the eyes of some billion-and-a-half people, Russia now is becoming such a leader, and it will take an immense effort to overtake her. The mere stepping-up of our missile program and sorting-out of our inter-service missile rivalry problems won't do the trick. Pooling our scientific know-how with our allies won't do it either. The problem is more basic.

It begins with the materialistic attitude toward modern day living and our indifferent attitude toward science. Lack of scientists? Of course! Scientists are individualists, and individualism is on the wane in this country. Must we remain at the point where it takes an Admiral Rickover to get things done?

Many of this country's outstanding scientists were born in Europe. Many of them came here to become citizens of this great country because they thought they could accomplish more in an atmosphere where one supposedly has intellectual freedom and a greater understanding of mankind's progress and of things to come. How disappointed these scientists must be today!

More than ever, Mr. President, we now need leadership. We are looking to you for this. We need uninhibited thinking at Cabinet level. We need a scientist at Cabinet level, a Secretary of Science. We also need a space flight program. We must consolidate and pool our scientific talent, possibly through a National Advisory Committee for Astronautics or an Astronautics Commission, with a definite schedule and timetable for the conquest of space. We must take the initiative to become first in satellite science. We must put man into space; we must put man on the moon and on our two nearest planets. The United States must show the way. If she does not, Russia will.

We must do all this within 20 years or less and we must start the planning for such a program immediately, for two reasons: 1) Such a program will yield tremendous scientific victories which will benefit our entire human race in numerous ways. 2) Such a program will restore supremacy to the free world and in particular to the United States. This, Mr. President, will mean for us a total

victory of democracy over slavery. Scientists and military planners must advance hand-in-hand to achieve this.

In order to accomplish this we must start at the basic research level. Instead of cutting funds for research and development, we must increase them. Research is the key to scientific and military achievement.

You now have the opportunity to reorganize our missile defense system and to start a space flight program. For the time being it is not so much a matter of granting more money for defense as a matter of organizing the expenditures and our scientific talent.

Obviously, we must spend more money in the future on a space flight program. John Q. Public understands the grave and alarming mess we are in, whether your Cabinet members do or not. He doesn't like to, but he will pay higher taxes if he can be assured that this nation will regain its Number One position in the world.

Actually, we have a lot of money in the bank for a space flight program. And we have the talent. *Jupiter* and *Thor* are duplicate programs initiated to perform duplicate functions. Seemingly one must go, but both have cost many millions of dollars; both have drawn heavily on available technical manpower.

The superficial solution is to decide that the full cost of one program and one missile team must inevitably be wasted—be lost to the country—a "necessary price" paid in the crash development of modern weapons.

This, Mr. President, is not so. There is a sound solution. If *Thor* proves to be the best weapon of the two IRBMs, do not cancel out the *Jupiter* team and money as a total loss, but shift the team and its hardware to America's inevitable space flight program. Special configurations of the *Jupiter*—or the *Thor*—are capable of putting up satellites of 1000 pounds weight. We could achieve this within months. Either missile represents a valuable piece of hardware for practically any preliminary space flight project. With this approach we can catch up with the Russians two to three years sooner —without slowing our military program—than if we repeat the approach we used in developing the *Vanguard* "me too" satellite.

The same technique can be used with our *Atlas* and *Titan* ICBMs. The missile not selected as a weapon must enter our future arsenal of space flight vehicles. So must the scientific team behind that missile.

Employing this approach, we will save the taxpayers millions, possibly billions, of dollars. The decision to pursue this goal and employ this technique must be made now.

Of course, we will have all kinds of investigations as soon as Congress convenes. And this is right. Senators and Congressmen need no urging to do something about our present confused situation; spontaneously they vow "something will be done about it" as soon as Congress convenes.

In all probability, Congress will throw some light on the confused background of our missile and satellite program. Incidentally, we hope Congress will also make public the names of the members of the nine-man committee that turned down the offer to use military hardware to launch the first U.S. satellite. It may be a waste of time to discuss at this time what we could have done and did not do. Nevertheless, for the record this is important. If nothing else, it will help sort out the incompetent from the capable, and it might give us a pointer as to where we will find the best-qualified scientists and leaders to conduct the kind of future space flight program this country so desperately needs.

We are not so sure that the U.S. is employing the best-qualified people at this stage of the game. Many missile industry people have questioned us about the capabilities of some of our current "space flight experts" (people who seem to have become space-minded overnight) and why we have not employed our true space flight scientists in the current IGY satellite program. We have no ready answer for them.

Yes, in the eyes of the world, the American satellite program now has become a "me too" project.

We urge you, Mr. President, to look at space flight as any other American institution, because sound, business-like competition would have put us out in front. The approach that has provided us with more washing machines and paved highways than the rest of the world also could have kept us the strongest nation in the world. No other approach will help us regain the ground that we have lost to Russia. No other approach will help us win the battle for the minds of men.

Those of us who talked with members of the Russian delegation at the space flight meeting in Barcelona recently heard these scientists all openly confirm the fact that Russia has a full-fledged space flight program. And you know, Mr. President, we don't have one!

The Russians have a definite timetable for their bigger satellites, for their different kinds of moon rockets and flights to the planets and manned, military space vehicles. In view of their technological advances in recent years—which they have proven beyond doubt—we can no longer afford to doubt any of their scientific claims.

Cost is of no importance to Russia. The Russian people might be starving; there may be a shortage of bread, soap, gasoline, clothing in the Soviet Union; but the world doesn't worry about this when the Russians send satellites and moon rockets aloft. Because this proves to the world that the Russians possess the ability to smash the Western World by missile bombardment.

Let us not fool ourselves, Mr. President; it takes more than power to put up a satellite. For years our missile engineers have tried to solve the structural problems created by high accelerations, tossing and stress in a missile, and for years they have tried to solve the guidance problems. Without solving these problems, you cannot launch a satellite. The Russians have solved them. We are still working feverishly to do so.

We must strip away this complacent feeling that we have held—that what the Russians can do, we can do better. This is probably true (for we undoubtedly have the better scientists). But in this race—and it is a race—the prize goes to the first achiever. The prize, of course, is world leadership.

The obvious lag in missile and satellite development could be fatal. It is not enough to say that for the present we have military superiority, which is doubtful anyway. We must demonstrate to the world our ability to exceed Russia in the scientific field and thus insure that free men will never become victims of communism through fear or default.

These potential new weapons are not toys. The nation that first controls space will control the world. The choice is democracy or slavery.

Let's get away from the attitude that the Russians "probably" haven't solved this problem or that problem. The launchings of their first *Sputniks* and space rockets are much, much more than "neat scientific tricks." You know it. The American people know it. And the American people expect you to do something about it.

You don't have to be a scientist, Mr. President, to solve this problem. You must be a leader.

ERIK BERGAUST

when and where

NOVEMBER

Second World Metallurgical Congress and 39th National Metal Exposition, International Amphitheater, Chicago, Ill., Nov. 2-8.

Institute on Electronics Management Meeting, Automatic Data Processing System, American University, Washington, D. C., Nov. 4-8.

Joint Military-Industry Guided Missile Reliability Symposium (security clearance required), Naval Air Missile Test Center, Pt. Mugu, Calif., Nov. 5-7.

IAS Weapons System Management Meeting, Statler-Hilton Hotel, Dallas, Texas, Nov. 7-8.

IRE, Instrumentation Conference and Exhibit, Atlanta, Georgia, Nov. 11-13.

Vickers Aircraft Hydraulics Conference, Park Shelton Hotel, Detroit, Mich., Nov. 12-13.

National Aviation Trades Assn., 18th Annual Convention Hotel Adolphus, Dallas, Nov. 13-15.

National Plastics 8th Exposition, International Amphitheatre, Chicago, Ill., Nov. 17-21.

International Air Transport Assn., Technical Conference, Miami, Fla., Nov. 18-29.

Aviation Distributors and Manufacturers Assn., 30th Meeting, Sheraton Cadillac Hotel, Detroit, Mich., Nov. 20-22.

DECEMBER

ASME Annual Meeting, Hotel Statler, New York, Dec. 1-6.

American Rocket Society Annual Meeting, Hotel Statler, New York, N. Y., Dec. 2-6.

High Temperature Strain Gauges, Symposium, Aeronautical Structure Laboratory, Naval Air Materiel Center, Philadelphia, Pa., Dec. 4-5.

ARS 1957 Eastern Regional Student Conference sponsored by the Polytechnic of Brooklyn Chapter, Hotel Statler, New York, N. Y., Dec. 6-7.

Gas Turbine Development Meeting, Speaker; Rear Adm. S. B. Spangler, USN, Air Development & Materiel Center, at Engineers Club, Philadelphia, Pa., Dec. 18.

JANUARY

IAS 26th Annual Meeting, Sheraton-Astor Hotel, New York City, N. Y., Jan. 27-31.

American Astronautical Society, Fourth Annual Meeting, New York City, N. Y., Jan. 29-31.

Seventh Annual Instrument Short Course, sponsored by Southern California Meter Association and Los Angeles Harbor Junior College, Wilmington, Calif., Jan. 30-31.

MARCH

Nuclear Congress, International Amphitheatre, Chicago, Ill., Mar. 16-22.

Aviation Division Conference, American Society of Mechanical Engineers, Statler-Hilton Hotel, Dallas, Tex., Mar. 17-21.

Atomic Industry Trade Show (in conjunction with the 1958 Nuclear Congress) International Amphitheatre, Chicago, Ill., Mar. 17-21.



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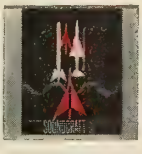
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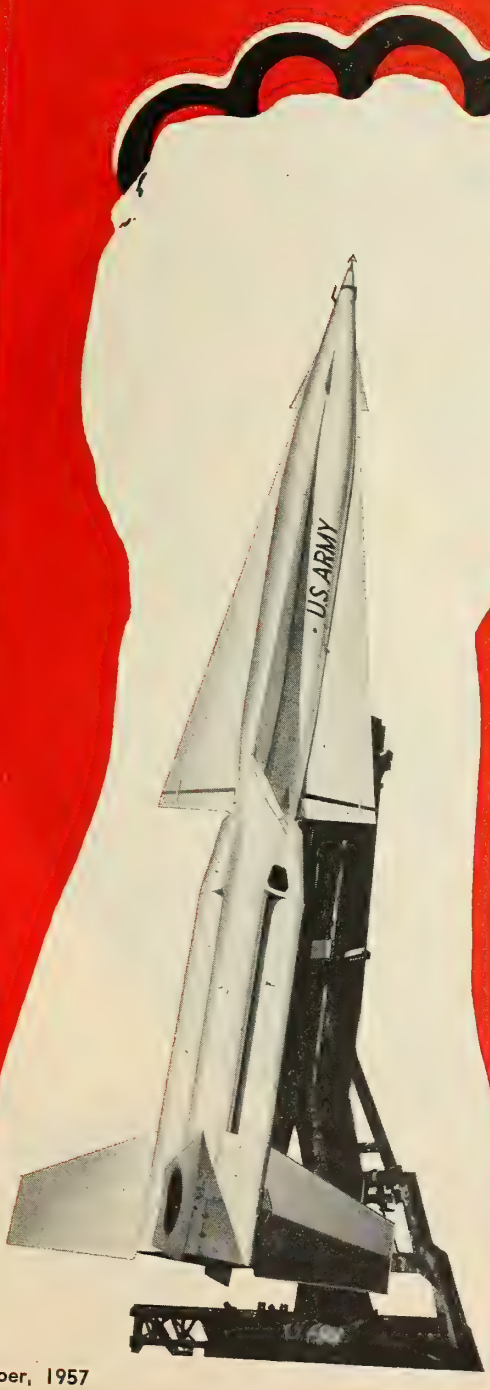
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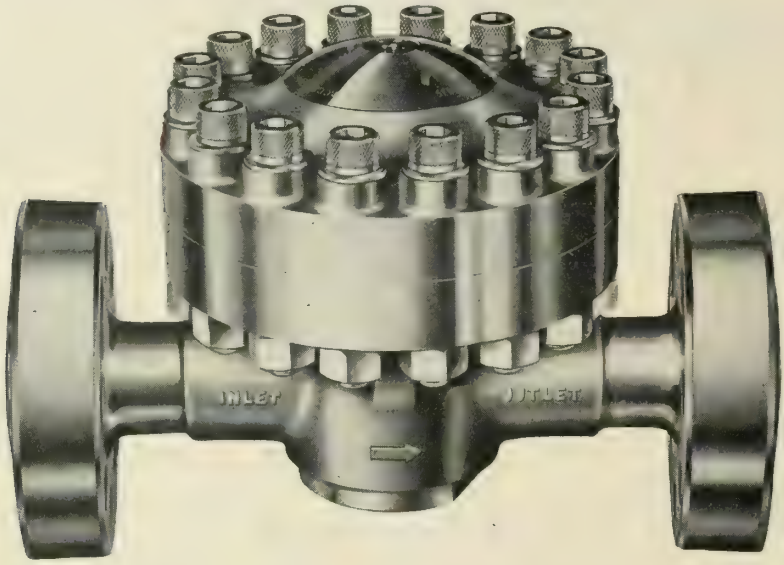
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...THE SERVO-DOME PRESSURE REGULATOR

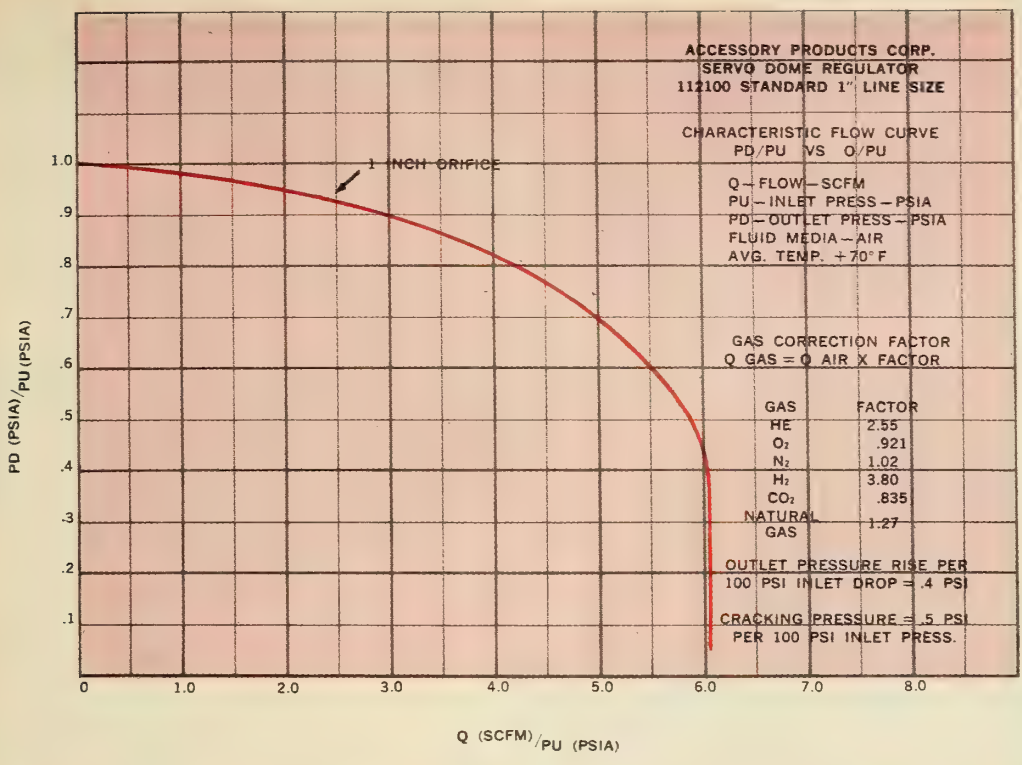
in stainless steel, aluminum, alloy steel, or bronze

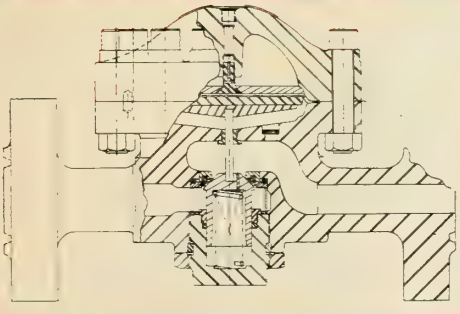
Reduction of initial air, gas or liquid pressures to optimum delivered pressure, and/or flow and continuous control thereafter...with extreme accuracy and operational versatility ... is now possible with APCO's new Servo-Dome Pressure Regulator.

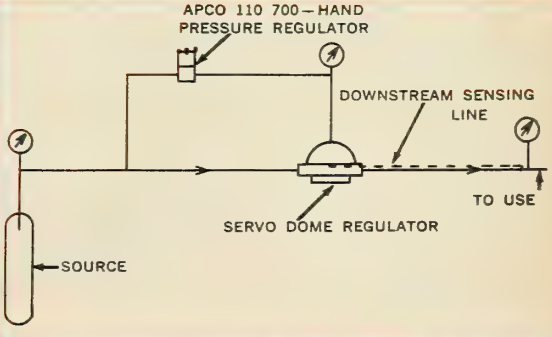


Check these outstanding performance features:

- ***Line sizes and orifice sizes from ¼" to 3", e.g. 3" line—3" orifice!***
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New high power type available



Typical Characteristics at 25° C	DT100
Maximum Collector Current	13 amps
Collector Voltage, Emitter Open	100 volts
Saturation Voltage (12 amps)	0.7 volts
Power Dissipation	55 watts
Thermal Gradient from Junction to Mounting Base	1.2° °C/watt
Nominal Base Current I_B (V_{EC} = —2 volts, I_C = —1.2 amp.)	-19 ma
Distortion (Class A_1, 10 watts)	5%

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The electronics industry asked for a transistor to handle higher voltage—and here it is—Delco Radio's DT100 with maximum collector diode voltage of 100 volts. This is the highest yet, and it paves the way for a wide range of new applications. The new DT100 is an alloy junction germanium PNP transistor—normalized to retain its performance characteristics regardless of age. You can depend on the uniformity, reliability and high current handling capacity of the DT100, just as you have in the past on all of Delco Radio's High Power transistors. Write today for complete engineering data.

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ANNIN...*most widely used remote shut-off valves for control of liquid propellants*

ANNIN's ten years of experience in the design and development of valves for rocket and missile ground installations has resulted in a new valve concept which has been *proven-in-service* for remote, manual and throttling applications. ANNIN's complete line is now available for pressures to 10,000 psi and temperatures from −400°F to 1600°F. Write for catalog 1500-C containing data on ANNIN valve bodies, operators and special design features.

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DIVISION OF THE ANNIN CORPORATION
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in **WEIGHT** ..... *as much as* 34%

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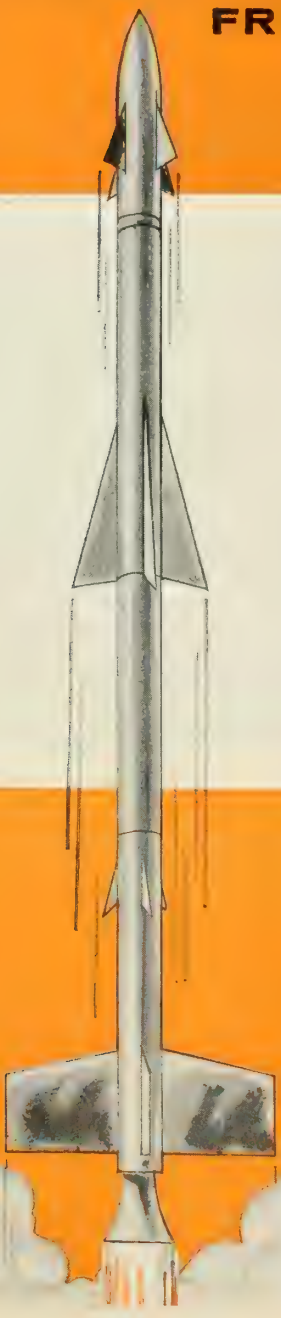
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Here's how you can stretch your present overloaded engineering and production facilities on missile projects . . .

Use the experienced designers at the Jet Division to develop structures, tanks, and other air-frame parts of your missile . . .

Use the complete facilities of our sheet-metal shop, welding shop, and machine shop to make these missile components . . .

Let our experienced tool designers and skilled press operators produce precision forgings in steel, titanium, and high alloys for the hardware on your missile. These forgings are so accurate in dimension and contour that most finish machining can be eliminated.

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WRITE FOR BOOKLET MR-557

which describes the experience, facilities and personnel of the Jet Division.



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CLEVELAND 17, OHIO

letters

Engineer Has Gripe

To the Editor:

May I pose a question to the rocket and missile industry: How can it be honestly stated that every effort is being bent to achieve the greatest progress in as short a time as possible?

Six years ago I contacted about 15 different companies in the airframe, engine and components fields about free radical applications for propulsion. The few replies I received fell into two basic catagories: 1) new idea, disclosure (give-away), 2) completely uninterested.

In May 1957, I sent out a brochure to 35 companies comprising the major airframe engine and research companies, outlining my approach to free radicals in rocket propulsion. The even fewer replies were the same as in the first case.

In the time between my first and second attempts to broach the field, I have designed, built and tested actual systems which could be flown and which are in existence today. I am now developing a more advanced system, and will test it in the near future.

Dr. Goddard, the man who founded RMI, and myself have one thing in common—we all had to use "backyard" methods.

Rocketry was of minor consequence in Dr. Goddard's day. Today the picture is very different. However, a person with a good idea still must resort to "backyard" methods because industry doesn't have the desire, initiative or vision to make any moves progresswise unless the government foots the bill right from the start.

Right now I wonder if and when I will be faced with challenging some company or corporation because of proprietary rights. All this is not a very good picture for anyone coming up with a valuable idea. I haven't found one company in any of the fields attendant to rocketry who would give me the opportunity to work on free radical propulsion, or even detail my work in order that they may judge for themselves. This includes the company I now work for, a rocket and missile prime contractor.

From my own experience over the past six years, I claim real progress and basic new ideas are government furnished, governmentally used and paid for by the government.

Gregory D. Noyes
8405 Loch Raven Blvd.
Towson 4, Md.

German Eye View

To the Editor:

With reference to a letter by Mr. Russell H. Jones, Jr., "A New Road to Controlled Fusion" (September), may I suggest tuning the cavities of the rocket engine shown for resonance frequency, finding critical absolute size limit and then shaping the whole thing for proper focusing of the shock waves, as shown in the old Hertz-Wiesner patent of Bergmann Ultraschall, 1954.

Perhaps the Russians are already using this principle in the powerplant of their *Sputnik* vehicle, since Hertz was in Russia at one time. What a blow for America's "baby satellites!" I would suggest scrapping the little balls and asking the Ivans how to do a proper job of "satellite throwing."

If you are interested in resonance combustion for fusion reactions in open-space combustion chambers, my partner, Mr. Bernard Olcott, 952 Fifth Ave., New York City, can show you how to boost specific impulse by 100% over what you will ever be able to do with chemical fuels in rocket engines. And all this can be done without the humbug of "sophistication" that the Western World fiddles with so unsuccessfully.

The Ivans know how to simplify things while still decreasing weight. They also know that nothing is happening in the U.S. despite all that security nonsense. This does no good, and actually holds back any real research work and prevents the poor American expert from getting any information from behind the Iron Curtain. America, in turn, knows nothing at all about what the Russians are doing because the Russians keep their mouths shut. They do a job without much fuss about "super-hyper-zip fuels." They just use simple swing laws and cheap fuels, probably solids or "frozen liquids."

Joseph Reder
Heidelberg, Germany

Suggestion Box

To the Editor:

Your column "Glossarifery" in the October issue is entertaining and light, though lacking technical information. Please continue it. It's enjoyable.

However, I am a trained technical, but non-professional man in the missiles and rockets field. I read and profit from

New Bendix SM-E Connector

(smaller, lighter than AN-E but equally dependable)

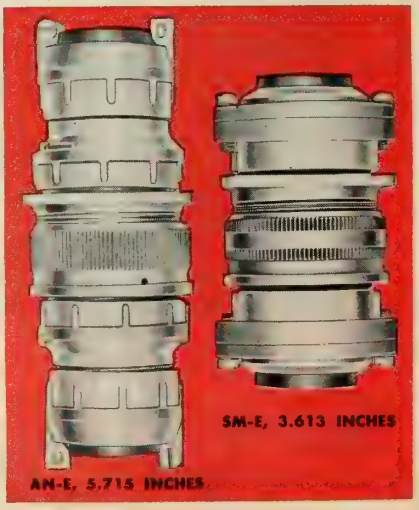


Here is the newest in the ever growing family of Bendix* environment resistant connectors. The new SM-E Series (Short "E") will provide the same performance as the standard AN-E connectors, but is shorter, lighter and more easily serviced. Not only does this connector conform to the vibration resistant requirements of the "E" connector in the MIL-C-5015C government specification, but it also provides effective moisture barriers both at the solder well ends and mating surfaces using the full range of wire sizes. Of particular interest to production and maintenance people is the back nut design, which provides a jacking action on the grommet during disassembly, thereby lifting it free of the solder wells. This feature when combined with the new Bendix "slippery rubber" grommets makes easy work of wire threading and grommet travel over the wire bundles.

Available in all standard AN shell sizes and tooled for most of the popular AN configurations.

Write for complete descriptive folder.

*TRADEMARK



Comparison based on size 40 mated assemblies. Space savings for smaller sizes are proportional.

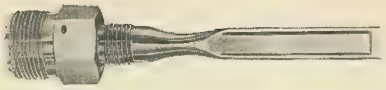
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EDISON'S RESISTANCE TEMPERATURE DETECTORS

wide range available for almost any type of use



MODEL 235N90-35
Designed for fast response and high resistance to the corrosive effects of rocket fuels used in guided missiles.
SPECIFICATIONS:
Stem-sensitive.
Useable temperature range —70° to +200°C.
Exponential time constant in agitated waterbath 0.8 second. Maximum hydrostatic pressure on stem: 750 psi at 100°C.
Basic resistance at 0°C = 90 ohms.
Hermetically sealed.



MODEL 242P
This Detector can be operated in live steam or high temperature atmospheres up to 1300°F.
SPECIFICATIONS:
Stem-sensitive.
Useable temperature range —70° to +750°C.
Maximum hydrostatic pressure on stem: 300 psi at 750°C.
Basic resistance at 0°C = 100 ohms.
Hermetically sealed.



MODEL 230N
A general purpose Detector for temperature measurement and control in industrial processes.
SPECIFICATIONS:
Stem-sensitive.
Basic resistance at 0°C = 120 ohms.
Hermetically sealed.



MODEL 166NC
Element is concentrated in tip for sensitivity to surface temperatures in motor bearings, etc.
SPECIFICATIONS:
Tip-sensitive.
Useable temperature range —70° to +300°C.
Basic resistance at 0°C = 120 ohms.

Rugged Edison RTD's are now available in 48 different types for use within indicating, recording, controlling and monitoring equipment. Adaptability of design and materials assures the construction of the best unit for each individual application.

Edison RTD's show marked advantages over conventional methods of resistance thermometry in any one of its many applications including: aircraft, missiles, missile fuels, pumps, motors, or anywhere temperature must be controlled and monitored. For one thing, they do not require signal amplification because they carry a potential of 1.5 volts sufficient to give an immediate indication on any type of instrumentation. For another, they give a time constant of less than ½ second because of their design (electrical bridge type) — a response time much faster than most industrial thermometer bulbs encountered.

The accuracy of metal RTD's is so great that the platinum RTD is the international standard between —190°C and +660°C. Edison RTD's tested years after manufacture show less than ± .05% change from the original calibration.

It will pay you to investigate the advantages of using Edison RTD's in your present or proposed temperature control work. Write for Brochure #3016.

Thomas A. Edison
INDUSTRIES
INSTRUMENT DIVISION
24 LAKESIDE AVE. WEST ORANGE, NEW JERSEY

McGRAW EDISON

your periodical. But—a lot of your jargon is above my head.

I offer here a sound suggestion: assist the technician in understanding the scientist.

How about setting aside a few pages each month for an honest to goodness glossary on missiles and rockets terminology. The real Noah Webster type.

I. G. Rooder

Convair Astronautics
San Diego, Calif.

Thank you for your suggestion which is under consideration.—Ed.

Asks Temperature Data

To the Editor:

In an early issue of MISSILES AND ROCKETS there appeared a chart of "Characteristics of the Earth's Atmosphere." One of the characteristics plotted is temperature, which shows a value of 1200°F beyond an altitude of 200 miles.

We are interested in learning how temperatures could be measured in such a rare atmosphere and what they really represent.

If you are unable to explain the method employed for measuring temperatures in outer space, perhaps you could give us the source of your information so that we could pursue this question further.

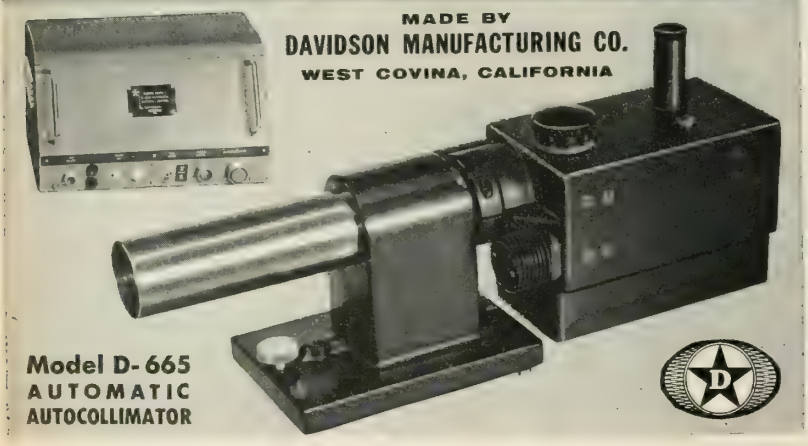
Erwin W. Tschudi

697 Thomas Ave.,
Baldwin, L. I., N. Y.

Temperature measurements have not been made at altitudes of 200 miles or above (pre-Sputnik). The values shown on the chart were obtained by extrapolation of known values at the lower altitudes.

One actual method of measuring temperatures at high altitude is by measuring the change in resistance in electric current through a wire.—Ed.

OPTICAL
measurement of angles
AUTOMATICALLY



MADE BY
DAVIDSON MANUFACTURING CO.
WEST COVINA, CALIFORNIA

Model D-665
AUTOMATIC
AUTOCOLLIMATOR

Astounding advances recently made by science and industry have created a need for detection of extremely small angular errors of variations for purposes of measurement, alignment or control.

Davidson has developed this Model D-665 Electronic Autocollimator to make available to industry for the first time a truly fast, accurate and sensitive angular measuring instrument.

Due in part to inherent sensitivity of completely transistorized electronics, and in part to elimination of human errors which characterize use of standard autocollimators, the Model D-665 offers you a much higher increase in sensitivity and greatly decreased response time than you can find in other instruments.

Angular readings appear automatically on a calibrated dial, one revolution of which equals 10 seconds of arc.

On the same shaft as the dial, a potentiometer is mounted, across which operator may put up to 125 volts. A voltage proportional to the measured angle is then obtained between the slider and center tap.

Two jacks are provided, across which appear either a positive or negative voltage, depending upon which direction the reflector is misaligned. They will be useful primarily in problems of alignment, when the dial is held motionless.

Ability to quickly detect exceedingly small angular changes and present them in convenient electrical form makes a Davidson D-665 Automatic Autocollimator the obvious answer for a wide variety of applications, many of which were impossible before this time.

CURRENTLY USED TO ESTABLISH AND HOLD AZIMUTH ALIGNMENT OF GYROSTABILIZED PLATFORMS

Wanted: "Angels" for Launching Bases

To the Editor:

This is a belated response to your proposal in "Missile Miscellany" in July that the American Rocket Society set up a missile launching base for "tomorrow's space-flight engineers, today's amateur missileer . . ." to "static test and fire their hardware."

I assume that this proposal was prompted by the letter from L. F. Megow, of the Rocket Research and Development Society, published in the same issue. Speaking as a member of an "amateur," nonprofessional society, may I suggest to the "manpower-hungry missile industry," that "would foot bill if ARS administered" that there is an organization that would probably jump at the chance. the American Astronautical Federation which has eight member societies.

So large and conservative an organization as that of the ARS must almost necessarily move slowly. Moreover, unless ARS attitude regarding amateurs has changed considerably from a few years ago, I feel rather pessimistic regarding any chance that the ARS would take up such a task in the near future.

The AAF was formed in 1954, five societies initially joining it. In three years membership expanded to eight societies, not including the Chicago Rocket Society which recently disbanded. These groups constitute almost an astronautic continuum in interests, experimental work, etc.

On the West Coast the Pacific Rocket Society and the Reaction Research Society have jointly purchased, and for over two-and-a-half years have operated, a testing area in the Mojave Desert. The two societies have developed new ideas and successfully launched what is believed to be the first hydrogen peroxide rocket constructed in the United States. There are active groups in Boise, Idaho; Salt Lake City, Utah; and State College. N. M. The Philadelphia Astronautical Society, to which I belong, has done work in liquid and solid propellants, although hampered by lack of adequate facilities. There is a student group at MIT. Cambridge, Mass. In addition, the rather widespread Society for the Advancement of Space Travel, also an AAF member, has headquarters in New Jersey.

I believe that from the framework provided by the member organizations and the national organization through the AAF constitution, a successful missile launching base could be set up, either through expanding existing facilities or establishing new ones. Furthermore, although the membership of each individual society is primarily nonprofessional and amateur, including many young members, professionals do belong.

If anyone is interested, may I advise that they contact the AAF President, Mr. Norris R. Peery of Intermountain Rocket Society, at 1425 Emerson Ave., Salt Lake City 5, Utah, or the AAF Secretary, Mr. Dale R. Smith of the Society for the Advancement of Space Travel, at 3001 Kyle Avenue, Minneapolis 22, Minn.

In ending, I must congratulate you for making such a proposal.

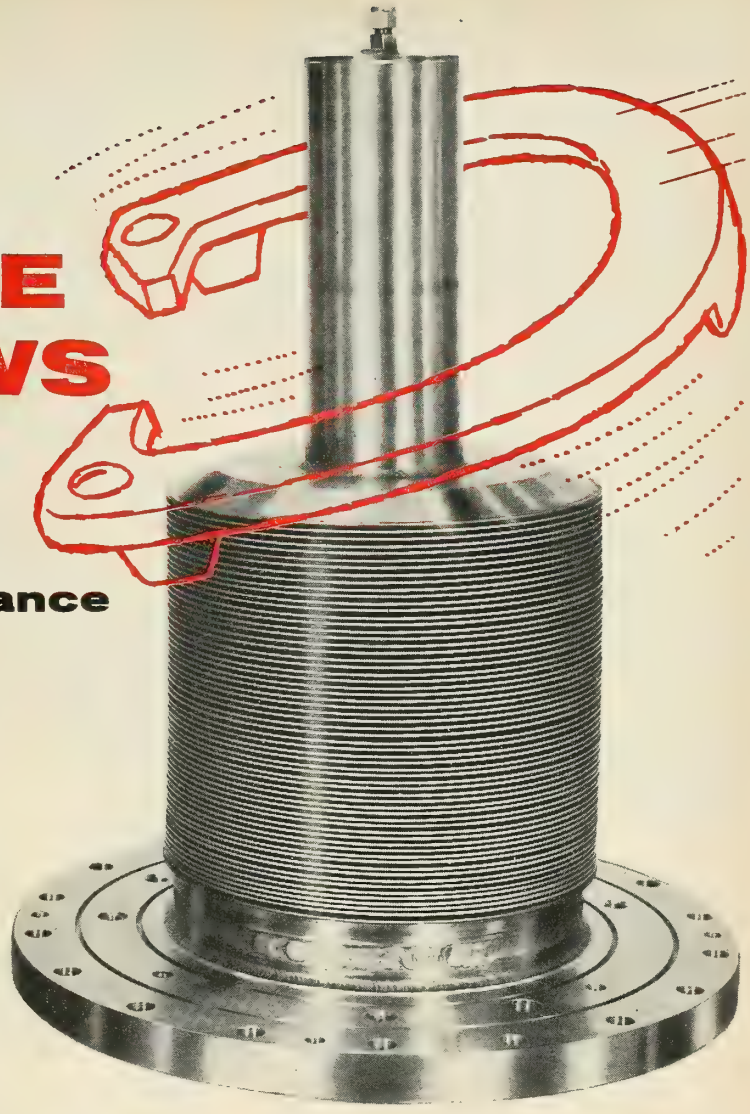
Leon M. S. Slawecki
Corresponding Secretary

Philadelphia Astronautical Society
3421 North Third Street
Philadelphia 40, Pa.

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BREEZE BELLOWS WIN

the tough game of high performance

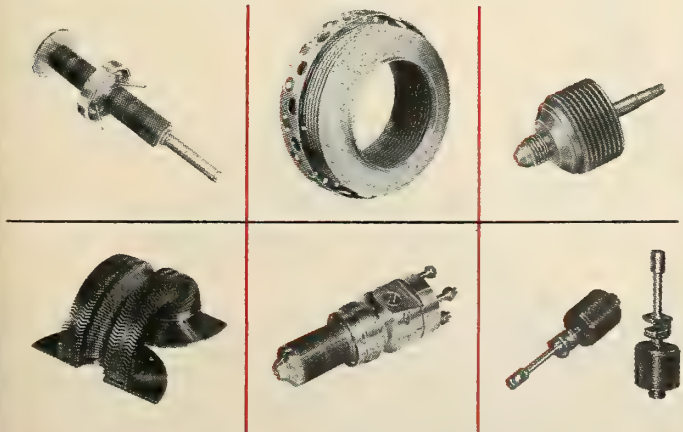


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We are solving critical problems in instrumentation, fuel regulation, pressure switches and expansion joints, hot air ducting, pressure surge tanks, packless valves, expansion and vibration joints, oscillating and rotating shaft seals, atomic and nuclear reactors.

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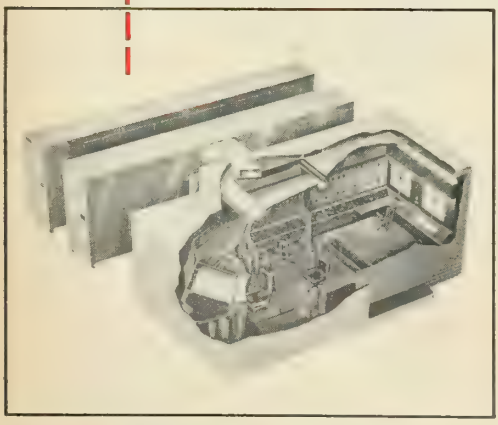
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PHOTO — COURTESY U.S. AIR FO

50,000 FEET UP-

with feet still on the ground



ERCO PROVIDES CRITICAL TRAINING FOR CREWS OF THE KC-135

The recent globe-circling feat of the SAC, B52 in the amazing time of 45 hrs. 19 mins. could have been 5 to 6 hours less — if the all jet KC-135 had been in operation to perform the refueling. Very soon the KC-135 will become fully operational and the crews of these giant 500 mph. tankers will be *fully trained* — thanks to the ERCO Flight Simulator. ERCO — one of the recognized leaders in the field of synthetic training devices was selected to design and build the KC-135 Simulator.

In addition to the KC-135 Floor Based Simulator shown here ERCO has designed, built and delivered more trailerized flight simulators than all other manufacturers combined.

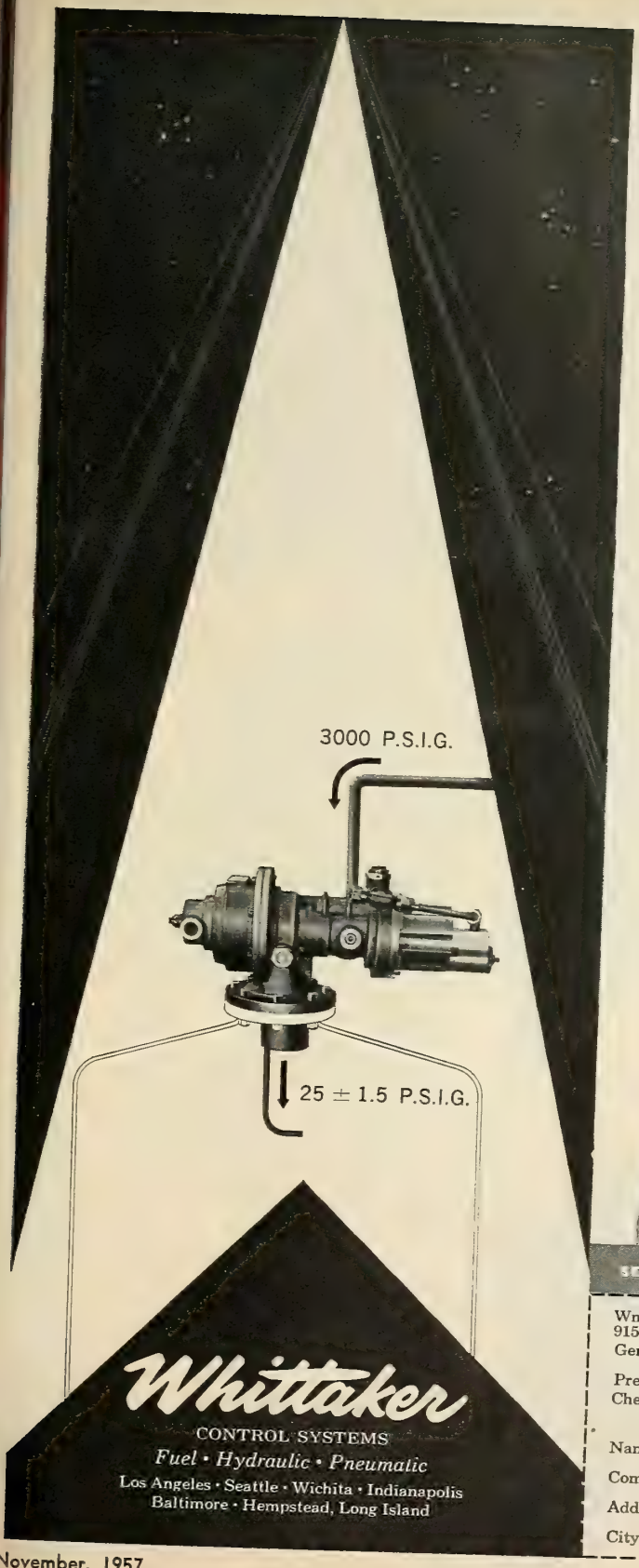
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fuel tank pressure limited to 25 ±1.5 P.S.I.G.

THIS NEW WHITTAKER PRESSURE ACTUATED REGULATING VALVE—designed to regulate and maintain tank pressure at a constant value—reduces high pressure helium or nitrogen to a low pressure and pressurizes fuel and/or oxygen tanks.

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This device includes two reducing stages to assure stable operation, regardless of flow variation, and is controlled by a remotely located sense line. This signals the actual pressure in the low pressure line leading from the unit to the tank.

This unit is now installed in one of the latest IRBM's. It is now in production, and with calibration settings changed to provide any specified request pressures, it can be used for many other applications.

This is only one of the many missile problems of all kinds that Whittaker has solved—and *is* solving every day! Whittaker's wide variety of talents are available to you now.

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TEMPERATURE	Ambient, −65°F to +160°F Fluid, −65°F to ±160°F
PRESSURE	Operating (inlet) 3000 PSIG (Outlet) 25 ± 1.5 PSIG pressure to be maintained in tank Proof 4500 PSIG – Burst 7500 PSIG
SERVICE	Nitrogen or Helium (in the presence of kerosene vapor)

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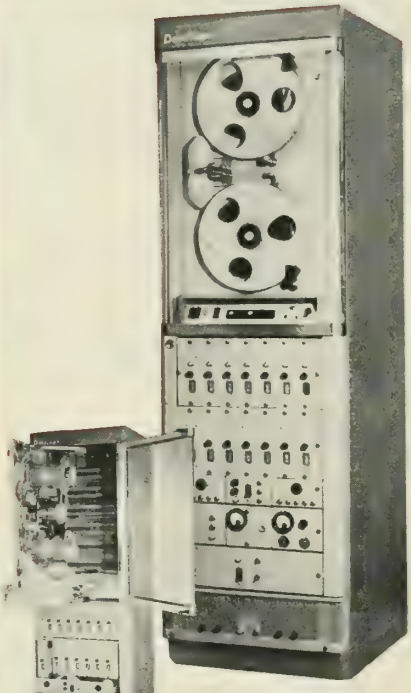
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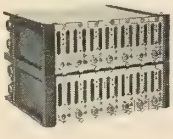
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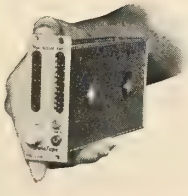
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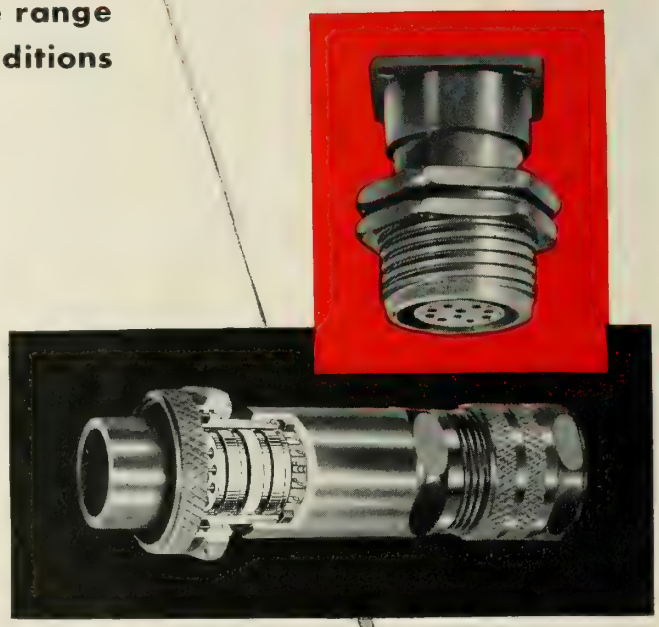
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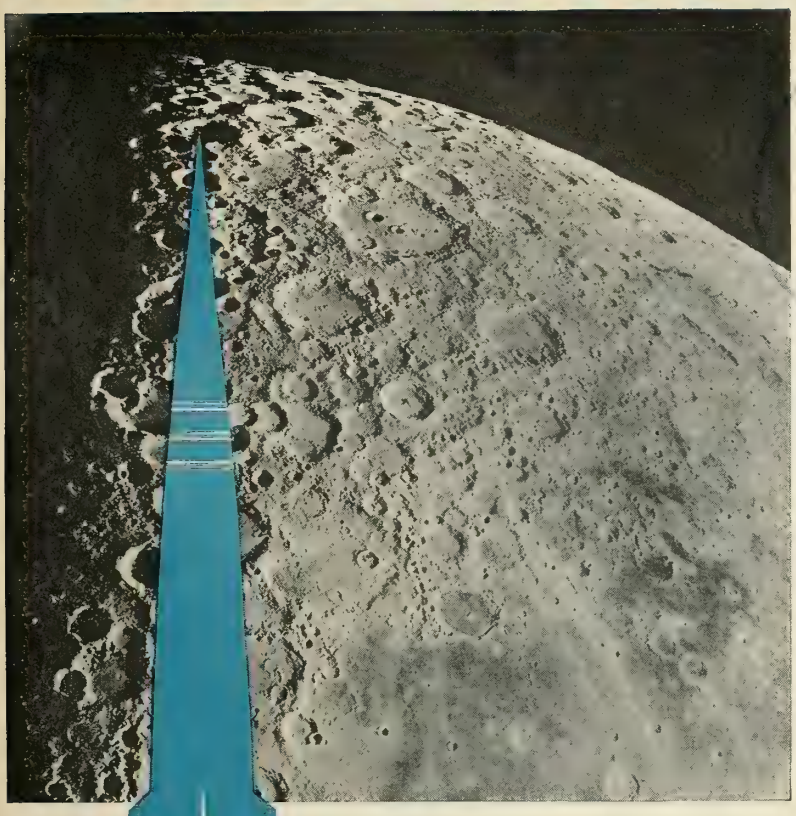
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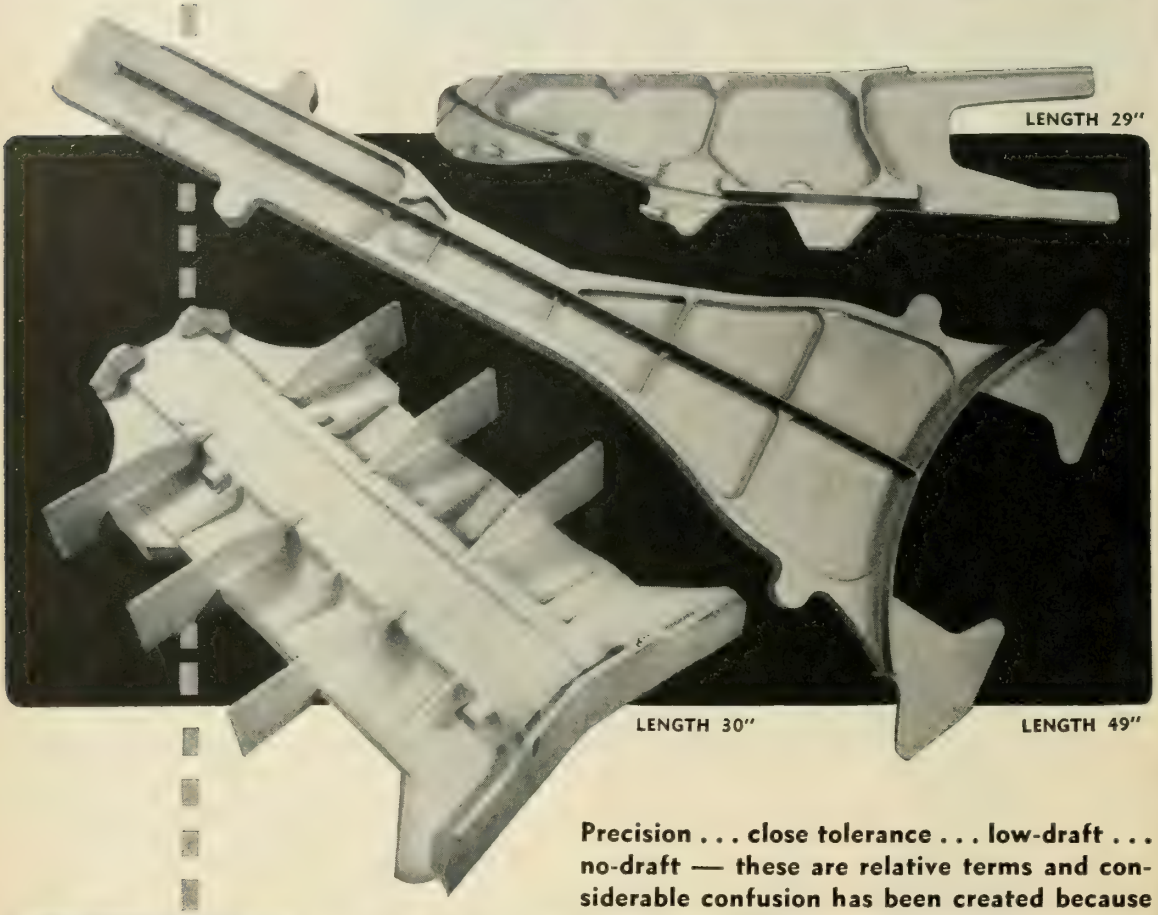
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Russia's Moon Rocket Program

Soviets Leap Ahead Again
Skip Bomber In Test Stage

By Erik Bergaust

BARCELONA—Details of Russia's moon rocket program were revealed to MISSILES & ROCKETS during the Eighth Congress of the International Astronautical Federation here. The expected news of Russia's technological victories in space flight science indicates the first lunar rocket may hit the moon before this issue of m/r goes to press. Furthermore, Dr. Leonid Sedov has confirmed to m/r that Russia's second satellite will carry a live passenger! A dog will be the first living creature to enter into an orbit around the earth. Dr. Sedov did not give a fixed date for this event but said it should occur about "the end of the month."*

The Moon is Next

This reporter learned exclusively from members of the Russian delegation to the IAF meeting that the moon comes next. When asked whether they have the hardware available or if they are building new launching equipment for any of their moon rockets, the Russians smiled and said Russia's satellite and moon rocket scientists are not concerned with this. "We just ask the military for the rockets—and they provide them. That's all." The Russian delegates were Academecian Leonid I. Sedov, chairman; Dr. Alla T. Massevich; Dr. Lydia Kurnasova; and A. Karpenko, secretary of the Commission on Astronautics, Academy of Sciences.

The immense significance of the above statement lies in the fact the Russians have an almost unlimited supply of workable, big liquid rockets available for space flight. Their T-4 engine, built for their manned skip-glide bomber vehicle which is now being test flown, yields a thrust of 820,000 pounds. When asked whether this engine will be used to propel their first moon rocket aloft, Dr. Sedov merely smiled and threw has arms out as if he couldn't care less what kind of engines would be used. (Dr. Sedov, at the seventh IAF congress in Rome last year, revealed exclusively to this reporter that Russia was working on several different kinds of atomic-powered rockets. The story appeared in m/r October, 1956.)



The race to the moon is on and Russia probably will win it. First comes the "direct hit approach"—with a little bit of luck, the Russians will do it.



Then, and this one is possibly more significant, comes the circumlunar vehicle. Eventually, this kind of rocket will carry cameras aboard.

Dr. Sedov—the great hero of the congress—also had some advice to Americans. He talked rather sarcastically about American interservice missile rivalry. When asked by an American delegate what he would have done after the first *Sputnik*, had he been an American, he said: "I would do something better and more significant." Of course, the American delegate agreed. But the sad fact remains—America is too far behind Russia to be able to match her in astronautics. So far behind, in fact, it is almost pathetic.

Moon Rocket Details

Dr. Sedov and his teammates were all smiles throughout the conference. They were joking and laughing happily, almost victoriously. And they most certainly had reason. Sedov told Dr. Fred Singer of Maryland University he would be happy to take one of the U.S. professor's cosmic ray counters aboard one of the next *Sputniks* since, apparently, Dr. S. F. Singer must wait a long time before he can have his equipment carried aloft in any American satellite..

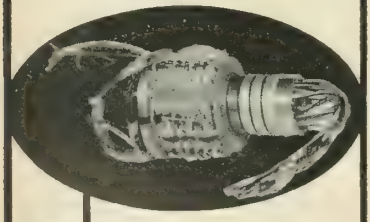
The Russian delegation was approached by many newsmen asking

**NOTE: m/r went to press at the time Russia announced* Sputnik *II.*



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questions about the Red missile program. But no comment was given by any of the Russians. As far as space flight is concerned, however, they were not afraid to talk.

From our conversations with the Red delegation, we can conclude the following facts about their moon rocket program:

1) The first Russian moon rocket will be launched just about the time this issue of *m/r* goes to press. If the attempt is successful, it will be advertised by the Russians as their big propaganda blow for the 40th anniversary of the Communist Revolution. If the rocket fails, the Reds will have some other stunt, such as flying their first atomic airplane, or a similar feat.

2) The first moon rocket may carry a payload of approximately 500 pounds and will be designed to either hit the moon or enter into an orbit around the moon. A radio transmitter will be aboard.

Reversed Thrust To Be Employed

3) The second type of lunar vehicle will be designed to retard its fall toward the moon by braking or reversed-thrust rockets and will plant itself and its transmitter intact on the moon's surface. The transmitter will send back to earth information on temperatures on the moon's surface.

4) The next type of moon rocket will carry television-type camera equipment that will relay back to earth close-ups of the moon's surface, possibly of the other side of the moon, never seen by man.

5) The fourth type might carry animals or even man—if the previous rockets have been successful and if the information gathered has been satisfactory enough to encourage manned trips into space. All this will happen within a few years.

The interesting point, of course, is that this sequence of approach has been discussed in this country and all over the world as the logical one for this kind of scientific-military adventure. The important thing is that the Russians are doing something about it and admit they are working hard to achieve these goals.

Man On the Moon in a Few Years

When this reporter asked Dr. Sedov whether he anticipated that man would establish an observation post on the moon in this century, he said: "Of course; at the rate we are progressing now, it shouldn't take too long." It's a sad thing to think about how Dr. Wernher von Braun outlined such projects for the U.S. government 10 years



Dr. Leonid I. Sedov, Soviet space satellite expert and well-known scientist, was the big hero at the Barcelona IAF meeting. Here he is trying to convince IAF president-elect Andy Haley the Russians will beat us to the moon.



And here he is being congratulated by the dean of aeronautics, Professor Theodore von Karman. The toasts to the Russians and their success were many. This one was in champagne. Sedov seemed to appreciate it.



During the technical sessions Sedov discussed scientific problems freely with delegates from many countries. Here he is offering Dr. S. Fred Singer of Maryland U. an explanation of some Soviet theory on cosmic rays.



Sedov enjoyed the social affairs and was intrigued by the Spanish folk dance festival put on for the IAF delegates. He is seen with spacemen Rolf Engel, center, and Redstone's Dr. H. H. Koelle. They, too, had a good time.

ago—and was laughed at and was almost thrown out the door of the Pentagon conference room.

Dozens and Dozens of Satellites

Members of the Red delegation confirmed that Russia would launch "many" satellites during the IGY—and after the IGY. When asked how many would be sent aloft during the IGY, the answers ranged from "a handful" to "about a dozen," which means that the Russians will be launching satellites of various kinds at a rate of almost one every five weeks. (So far they have done considerably better than that.)

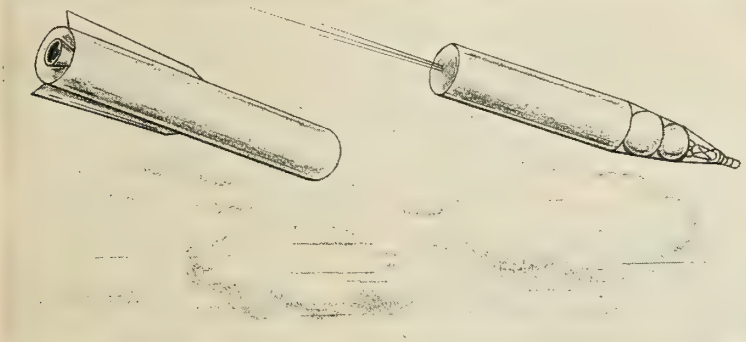
Sedov indicated that Russia's moon rockets and "other space vehicles" would be launched independently of their IGY satellites. He offered a remarkable comment in this connection: "One should not be so overwhelmed about these things; like America, we committed ourselves to launch a series of satellites during the International Geophysical Year. We're just doing what we said we would."

nated the technical session with some 25 papers (only a few of which were good), against two or three papers from any other country.

The press was disgusted, confused and frustrated over the complete lack of preprints of papers, press facilities, translations and liaison. Official press conferences were few and handled so poorly that many newsmen walked out in the middle of them. Furthermore, anyone who felt like giving a statement to the press arranged his own press conference. The Americans were great at this. Of course, the Russians did not hold any press conference. To quote Dr. Theodore von Karman: "The Americans are talkers; the Russians are doers." Dr. von Karman also criticized the quality of many of the American papers.

Durant Opposes U.S. Vice President

But there's hope for the IAF. Andy Haley was elected president for 1958, and he has promised a hectic, progressive year for the organization. Already he is busy at work planning the next congress, to be held in The Netherlands. The 1959 congress probably will be held in Moscow; 1960 in Stockholm, and 1961 in Washington, D.C.



Russian drawing of rocket vehicle designed to land on the moon's surface, employing reversed thrust rocket in the nose for braking.

Inferior IAF Congress

IAF's new president, Washington, D. C. attorney and well-known space lawyer Andrew G. Haley, had some discussion with Sedov on the subject of space law and jurisdictional aspects of moon exploration, but Sedov did not commit himself in terms of whether the Russians would claim ownership of the moon once they've planted their flag there.

Had it not been for the launching of the first *Sputnik* and the presence of the four-man Russian delegation, the Eighth Congress of the International Astronautical Federation would have been a complete flop.

The meeting was almost completely disorganized. In spite of beautiful Spain and its hospitality, in spite of the Spanish host society's honest efforts, the meeting was amateurish from beginning to end. Americans dominated the technical session with some 25 papers (only a few of which were good), against two or three papers from any other country.

Mr. Haley suggested current American Rocket Society President Robert C. Truax for IAF vice president for 1958, but Frederick C. Durant III apparently pursuaded Haley to reconsider. Haley withdrew his proposal. Thereafter the following astronauts were elected vice presidents: Acad. L. I. Sedov (USSR), Prof. Zarankiewicz (Poland), Dr. L. R. Shepherd (U.K.), Ing. A. Hjertstrand (Sweden), Dr. J. M. J. Kooy (Holland) and Prof. T. M. Tabanera (Argentina).

Asiatic flu took its toll during the Congress. Brig. Gen. Toftoy, Rolf Engel and an R.A.E. representative were each out for a few days with high fever. Sedov managed to carry through until Saturday before he, too, succumbed.

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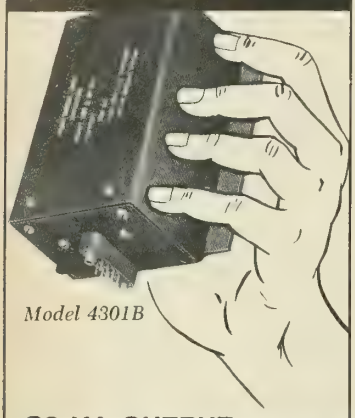
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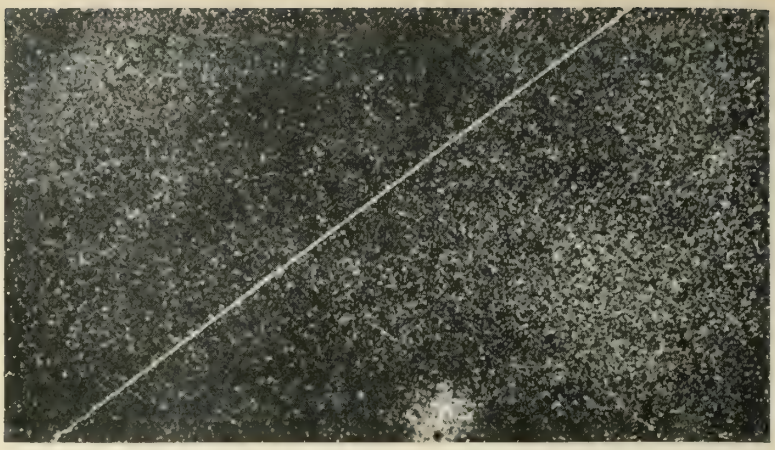
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How Accurately Was *Sputnik* Launched?

To find out, the editors of m/r consulted Dr. S. Fred Singer, who made accuracy and lifetime calculations for Project *Mouse* in 1954. Here is what he said:

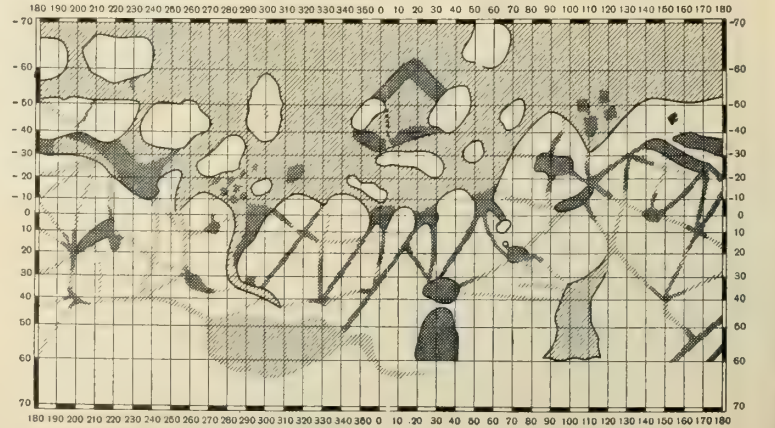
"We are not sure of the release altitude of the Russian satellite (burn-out altitude of the last stage), but we can be sure that it was not less than 200 miles. For a lower release altitude any small error in release angle is fatal because of the dense lower atmosphere. Higher altitudes of release are desired, since they give more latitude against guidance errors.

"With *Sputnik*'s reported orbit, initial perigee and apogee 140 and 560 miles respectively, I get the following results:

Launch Altitude Miles	Velocity Error	Release Angle Error
375	−0.2%	2.8°
190	+1.8%	1.75°
140	+2.6%	0.0

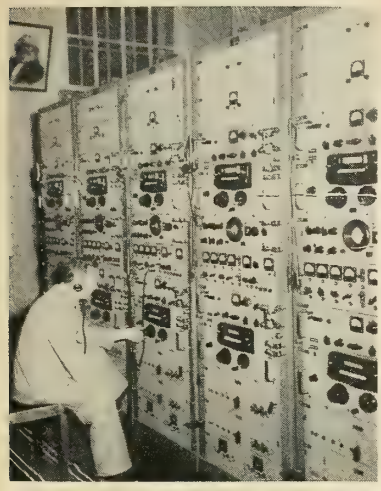
"The release altitudes are chosen to bracket the probable value. The lower altitude is most unlikely due to reasons stated above. The angular error in these calculations is astonishingly large. It's sufficiently good enough for a satellite but not good enough for an ICBM.

"The answer must be that their ICBM guidance system is too heavy for the third stage of their satellite rocket. It is doubtful if they could hit the moon with this kind of guidance without a great deal of luck. Thus, *Sputnik* doesn't necessarily prove they have ICBM capabilities, only that they have a large rocket. On the other hand by itself it doesn't prove they don't have an ICBM either."



Recently released map of Mars published by Russian astronomers.

Super Control Center for Soviet Satellites



Moscow has a super control center for tracking of satellites. Permanent observation of the *sputniki* is conducted at various radio stations, such as the one shown in the above picture. The control center and the radio stations are operated by the Ministry of Communications of the U.S.S.R. near Moscow, under direct supervision of the Commission on Interplanetary Travel. The Soviets have informed us the engineer shown here is Ivan Pryzhkov—eagerly listening to the signals from *Sputnik* II.

Reds Build Huge "Brains" for Nuclear Calculations

The Soviets have built a machine that "multiplies 15-digit numbers at the rate of 500,000 actions per second, and adds such numbers at the rate of two million actions per second."

A problem in nuclear calculations which only a year ago would have required six months' work can now be done on the new computer in about one day.

The Soviet Academy of Sciences has a special computing center in Moscow, whose chief, Academician A. A. Dorodnitsyn, said recently that in one year his center's best computer did the work that would have required the efforts of 10,000 human calculators laboring not less than 20 years. This electronic computer takes less than 20 hours to solve problems "requiring 250 million actions in arithmetic." The computer is serviced by a team of only two engineers and one technician per shift.

Besides Moscow, main Soviet centers of electronic-computer improvement, production, functioning, and engineer training are Penza in east European Russia; Erevan, capital of Soviet Armenia; and Kiev, capital of the Soviet Ukraine.

The Kiev computing center is one of the most recently established in the Soviet Union. The giant computer, now being built for it, is already in partial operation. In one eight-hour working day it performs "the work that can hardly be completed by 100 experienced mathematicians laboring 10 years."

Red Star Reprints American Missile Map

Referring to it as "forced fear" the Soviet army newspaper *Red Star* recently reprinted a map originally used by U.S. News & World Report.

Showing the United States under a circle of Soviet ICBMs, the map is entitled "Russia Could Reach Target in the U.S." The map was cited as more evidence of American warmongering.

Moscow Shocked by Guided-Missile Toys

Under the banner headline, "Imperialism Breeds Murderers and Violators," the Moscow Komsomolskaya Pravda accuses the U.S. of deliberate encouragement of the sale of guided-missile toys.

"On the counters of American toy stores it is now hard to find the heroes of old fairy tales—those good-natured teddybears, those shy long-eared rabbits," the Red newspaper charges. Instead, U.S. customers have to buy all sorts of miniature weapons, particularly "atom bombs and guided missiles which fly, shoot, explode, destroy toy cities, and kill toy people."

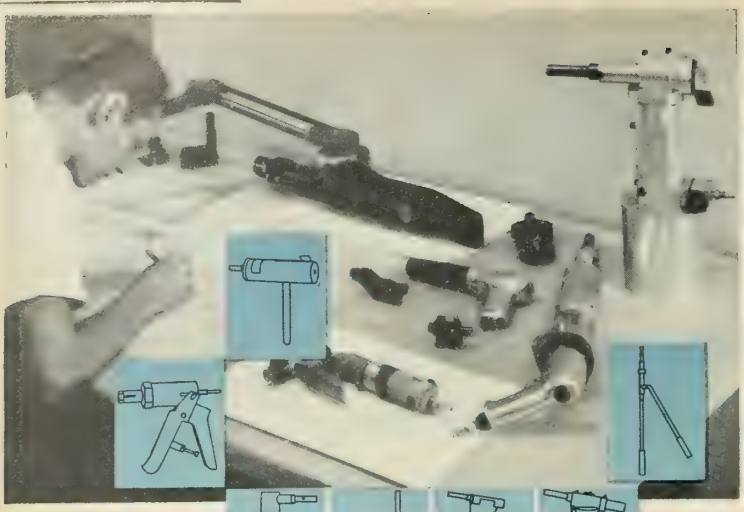
The Russian article is accompanied by a picture showing an American boy, who, the Moscow editor explains, is a seven-year-old lad named Eddie, "full of happiness because he has an atom gun and a guided-missile installation which shoot and explode like the real thing."

Cushioning Cosmic Drop Attempted by Reds

Measures to protect a person "passing from airless space to the lower, solid layers of the atmosphere" are now being worked out by Soviet experts in cosmic medicine. This was announced at a recent Moscow meeting by Professor P. K. Isakov, a Stalin Prize winner and chairman of the Soviet State Committee on Cosmic Medicine.



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Prototypes of new special tools for installing Cherry Blind Rivets and Lockbolts are shown in the Cherry Research and Development Department.

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for building tomorrow's aircraft being developed today by Cherry research

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This activity—anticipating the needs of the aircraft industry and the military—is an old story with Cherry. For years, Cherry engineers and technicians have devoted themselves to a single objective—the production of better aircraft fasteners and the tools for installing them.

Tools for solving specific problems—tools for efficient production fastening—all are developed and produced in the Cherry plant at Santa Ana which is devoted exclusively to the production of fastening equipment for the aircraft industry.

For information on the most efficient fastening methods for your operation—write Townsend Company, Cherry Rivet Division, P. O. Box 2157-Z, Santa Ana, California.

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Reds Reveal Scientific Plans

The Soviets now claim they have the world's largest installation "to capture and study broad lines of cosmic rays" as these particles of "ultra-high energies, messengers of cosmic spaces, penetrate the earth's atmosphere." According to *Komsomolskaya Pravda* the "unique machine," installed in the Lenin Hills of Moscow, has "five thousand registers."

Izvestia reveals that the Riga "Hydrometpribor," on Latvia's Baltic shore, is a leading Soviet factory producing precise instruments in the field of physics. Recently the Riga plant has made 100,000 of the instruments required for the Russian part of the International Geophysical Year. The scientists of the Moscow University are collaborating with the engineers and designers of the Riga plant in creating some of these instruments.

Russian LOZ Work Dates Back to '50

As early as 1950, the USSR had available pure, liquid ozone for research and limited development. Initial work on LOZ was begun around 1947 at several universities in the Moscow area, notably the University of Moscow and M. V. Lomonosov State University. By 1951 they had succeeded in stabilizing and producing enough LOZ so that it could be used by other personnel and for other basic work. For example, for some five years, the Russians have been using LOZ in an attempt to synthesize hydrogen superperoxide—H_2O_4. This latter compound, arrived at via LOZ and bombardment techniques, may in reality be a polymer of HO_2 (perhydroxyl). Key people in the Soviet super-oxidant projects are: A. P. Purmal, N. I. Kobozev, L. I. Nekarsov, and E. N. Eremin. Purmal's work is being carried out at the D. I. Mendelev Chemical Technology Institute at Moscow.

Soviets Build Bolometers At Academy of Sciences

The Institute of Physics at the Soviet Ukrainian Academy of Sciences announces that it has successfully tested and begun mass production of an extrasensitive bolometer "to measure the temperatures of revolving parts of machinery and to help in astronomical and allied researches." The apparatus is claimed to register such "minute changes in heat as one-millionth of a degree."

R

RAPID

RACE* eliminates slow, time-consuming manual tests by electronically checking complete weapon system such as missile or aircraft. Operating on initial assumption that system is functioning properly, RACE speeds through primary test of over-all system or major sub-systems. If fault exists, RACE signals "no-go", then isolates fault through secondary tests. Complete job is done in only minutes.

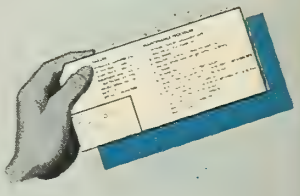


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AUTOMATIC

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1009 HOURS

C

CHECKOUT

RACE not only pinpoints weapon defect —it also flashes on control console screen location, name of faulty unit, down-time involved, location of spare, type of technical work required, system power and arming conditions for safe repair. Simultaneously, punched maintenance card with complete, detailed instructions for repair is automatically ejected.



1025 HOURS

E

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Design flexibility adapts RACE for use at operational sites in pre-launch and pre-flight check-out, for in-flight testing, for maintenance areas and overhaul depots. Current and future applications include missile data reduction stations, shipborne and airborne radar, automatic navigation systems, aerial reconnaissance systems, ground fire control systems and missile guidance systems.



1030 HOURS

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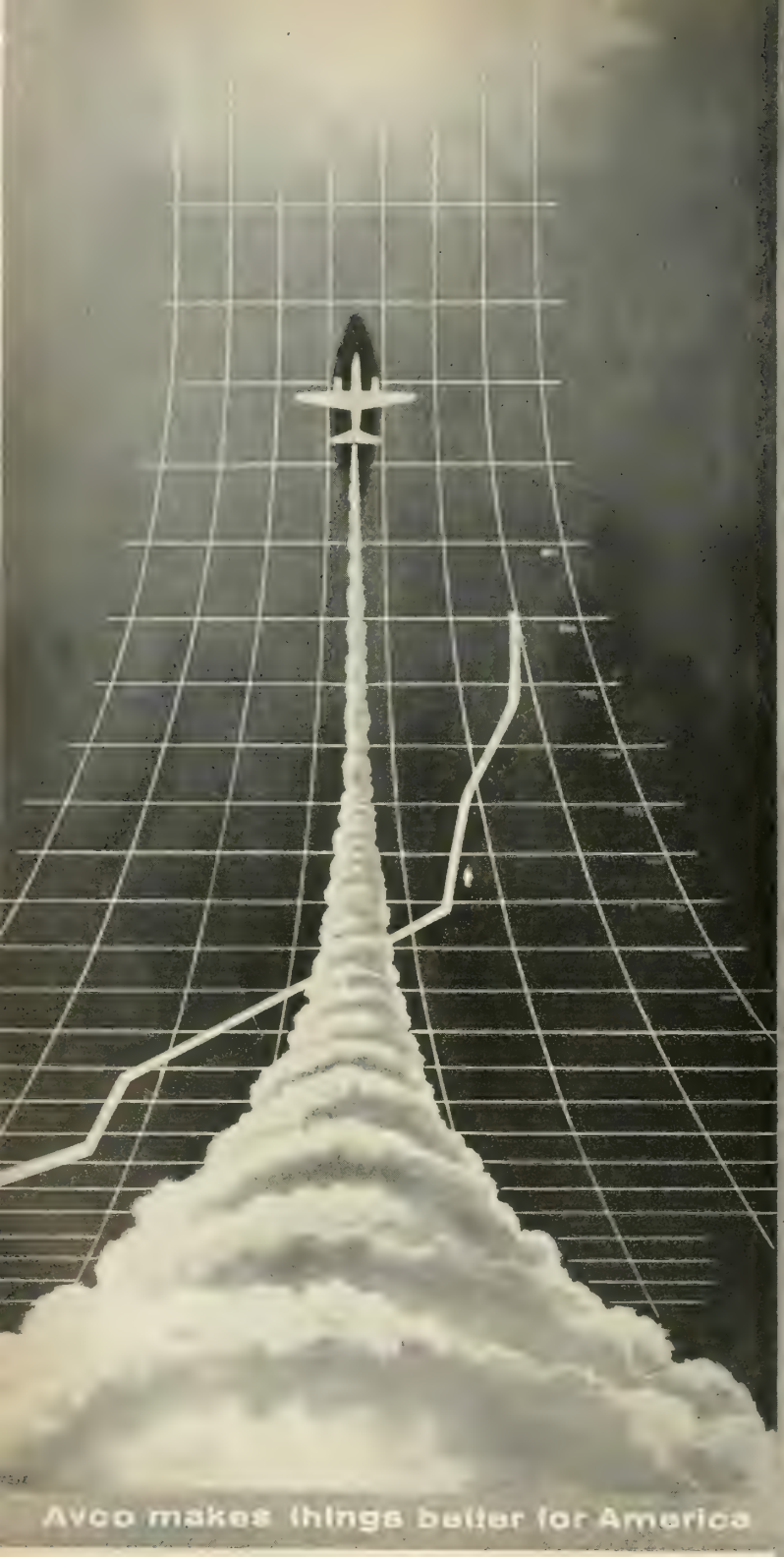
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There Wasn't a "Trick" to be Heard

World reaction to *Sputnik* II was like that to its predecessor but with these differences: nobody called it a "trick," and there were loud wails from dog lovers.

Renewed cries went up for a special session of Congress and a speedup of our missile program.

• Sen. Henry M. Jackson (D-Wash.) called for a missile "czar" and the launching of a "bold program" for increasing scientific and engineering training. "Moscow is now in the process of taking away America's historic trump card—its industrial and scientific supremacy," he said.

• Sen. Allen J. Ellender (D-La.) said it showed "the West has had its head in the sand too long," but that we are not trailing the Russians in the missile field. "They just beat us to the punch."

• In Japan, Masashi Miyaji, head of the Tokyo Astronomical Observatory, objected that the Russians did not announce the launching in advance.

• A group of scientists at Stanford University, Palo Alto, predicted that *Sputnik* II may continue to orbit for "100 years or more."

• Two reactions from top Defense people when asked if we would now speed up our missile program: Gen. Nathan F. Twining, chairman of the Joint Chief of Staffs, said, "What do you think?" Defense Secretary Neil H. McElroy said it would have no great effect. "We already are in a pressure program."

• Mrs. Irene Enzinger, founder of the Orphans of the Storm Animal Shelter, in Deerfield, Ill., spoke up for shocked canimaniacs all over the world, condemned such use of dogs as "disgraceful and cowardly," since the dogs "have no chance to speak up as to whether they want to be used in these experiments."

Excellent Progress at Martin Orlando

The first production *Lacrosse* missile manufactured at The Martin Company's new Orlando, Fla. facility, has been delivered to the Army less than 11 months since the start of construction on the plant.

This is indicative of the outstanding progress that is being made by The Martin Co. in placing their latest missile plant in full operation. The plant, being built in a pine forest nine miles southwest of downtown Orlando, will be completed this year. Installation of machinery was begun on Oct. 1. The first contingent of personnel will begin moving in Dec. 1.

The Martin Co. engineered a remarkable logistical operation in the rapid move of *Lacrosse* manufacturing from Baltimore to Orlando. A temporary building for *Lacrosse* manufacturing was leased in late October last year. A nucleus of manufacturing personnel was moved in that month. Machinery move was completed by February. One month later, the Army accepted the first *Lacrosse* missile produced in Orlando.

The company-owned plant will also produce the air-to-surface *Bull Pup* for the Air Force.



Outstanding rocket propulsion scientists Frau Irene Bredt-Sänger and husband Dr. Eugen Sänger who believe the Russians have been activating their skip-glide bomber project and that their T-4 engine is in production. The T-4 engine yields 820,000 pounds thrust and might have been used to launch SPUTNIK II.



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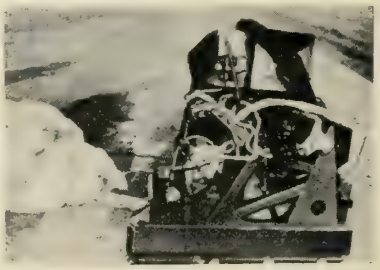
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Shooting Dogs into Space Old Hat to Russians

The Russian decision to use *Kudryavka (Curly)*, the dog, as the first warm-blooded space traveller was based on many years of successful experiments with dog "guinea pigs."

Several Russian animals, particularly dogs, have made high-altitude flights in rocket vehicles. A recent flight attained an altitude of 130 miles. The dogs were returned to earth by parachute and, according to Soviet scientists, survived the flights without mishap.

Apparently Russia was not prepared for the onslaught of world-wide denunciation of the experiment. Early



Russian space dog and rocket gear.

reports stated that *Kudryavka's* space cabin would be ejected from *Sputnik II* and would be returned to the earth by undisclosed means.

A. A. Blagonravav, top Soviet satellite scientist, has since disclosed that recovery of the capsule will not be possible. Another scientist has stated further that *Kudryavka* is not expected to live for more than 10 days. This may indicate that the dog's oxygen or water



Dog landing safely in parachute container.

supply will be depleted by that time.

Meanwhile, some U.S. officials involved in IRBM and ICBM nose cone development, have expressed the conviction that recovery of the capsule is possible if Russian developments in this field are on a par with U.S. developments.

The velocity of the satellite or capsule would have to be reduced at least 60 per cent before it reached the denser atmosphere below the 20-mile level.

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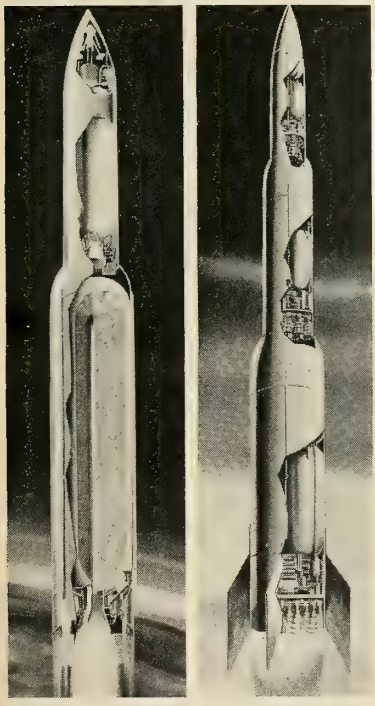
Research Rocket Flights Made off Cape Charles

ABOARD USS *LAUNCHER*—A series of research rocket flights are being made from the deck of this converted LCT (Landing Craft Tank). As part of a University of Maryland program under the direction of Dr. S. Fred Singer, eight high-altitude rocket flights are now in process with the object to obtain additional data about conditions in the ionosphere.

The program includes four flights by *Terrapin* (designed by the University of Maryland and manufactured by Republic Aviation) and four flights by *Oriole*, designed and manufactured at the University of Maryland. Experiments being conducted include the release of sodium vapor at 80-to-120-mile altitudes, the release of nitric oxide and the creation of artificial meteors. There will also be one shot of a flash bomb by the *Oriole*, in order to pinpoint its trajectory and thus, altitude.

The *Oriole* is a new "university research rocket," designed by Richard Bettinger, a graduate student at the University of Maryland. Using an Army *Loki* as a booster, *Oriole* is so simple that it's revolutionary. Depending on whether its "sting" is three-quarter inch or one-and-a-quarter inches in diameter, it will take a scientific payload to 80 or 120 miles altitude. Separating from the booster at the end of its 0.8-second burning time, the finless, unflared sting coasts to its peak altitude. With the *Loki* is provided free by the Army, the whole unit costs less than $300, less payload. It uses a standard *Loki* spin launcher adapted to the light-weight breakdown *Terrapin* launcher.

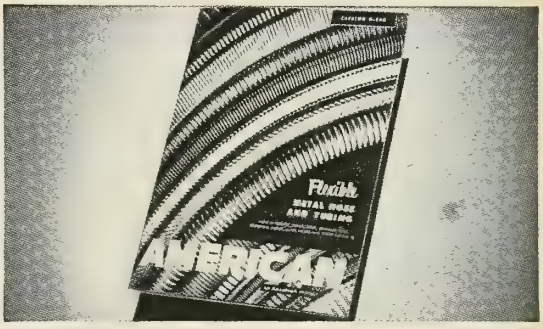
NAA Super Rockets for Mars and Venus



We don't lack ideas in this country when it comes to space flight. We just don't do much about realizing them. Here, for example, are a couple of North American artist's conceptions of solid-liquid and liquid (right) rocket vehicles designed for travel to Mars and Venus. The rockets are based upon available hardware. How about it, Mr. McElroy?

Jupiter is Accurate

The sixth *Jupiter* took off on a 1500 mile firing recently to fall within two and one-half miles of its ten mile target center.



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Prince of Hannover

Andrew Haley, president, International Astronautical Federation, and Dr. Welf Henrich, Prince of Hannover and author of the first doctoral thesis on space law, are embarking on the first nationwide space law lecture series this month.

Their itinerary follows:

Nov.	Place	Sponsored by:
4	Princeton, N.J.	Princeton Univ. & ARS
	New York, N.Y.	Physician's Sci. Soc.
5	Detroit, Mich.	Univ. of Detroit
	Ann Arbor, Mich	Univ. of Mich. & ARS
6	Chicago, Ill.	Univ. of Chicago
	Chicago, Ill.	Northwestern Univ. & ARS
7	Madison, Wis.	Univ. of Wisconsin
	Rochester, Minn.	Mayo Clinic
8	Minneapolis, Minn.	Univ. of Minnesota & ARS
10	Butte, Mont.	Civic Group
11	Missoula, Mont.	Montana State Univ.
12	Spokane, Wash.	Gonzaga Univ. & County Bar Assn.
13	Seattle, Wash.	Civic Group
	Seattle, Wash.	Univ. of Wash. & ARS
14	San Francisco, Calif.	Univ. of Calif. & ARS
15	Los Angeles, Calif.	Univ. of Calif. & ARS
18	Salt Lake City, Utah	Civic Group
19	Holloman AFB, N.M.	ARS
20	Denver, Colo.	Civic Group
22	St. Louis, Mo.	St. Louis Univ., Wash. Univ. & ARS
25	Cambridge, Mass.	Harvard Univ. & ARS
26	Washington, D.C.	George Wash. Univ., Georgetown Univ. American Univ., Catholic Univ., Univ. of Md. and ARS

Cryostat at Lockheed To Make Liquid Helium

Lockheed is installing a cryostat for the production of liquid helium at the research laboratories of its missile systems division in Palo Alto. Prime purpose for the super-refrigerator that can produce temperatures cold enough to freeze moving molecules in their tracks, is Lockheed's own research, but it will also make the liquid helium commercially available to other scientific groups.

Eight San Francisco peninsula firms have already expressed a need for 400 liters per month. Capacity of the Lockheed cryostat will be about 1000 liters a month. Lockheed's missile division is studying the use of liquid helium as a low-temperature bath for electronic and other devices, and it also is conducting studies in certain unusual properties of the helium itself.

More Money for *Jupiter?*



HUNTSVILLE, Ala.—A supplemental appropriation, perhaps as much as $75 million, is believed to be wending its way through the Pentagon for the *Jupiter* program. Intended for accelerated development and testing of the IRBM, the money is presumably coming from Department of Defense funds to continue financing *Jupiter* when the current contingent fund of some $35 million runs out. This is accompanied

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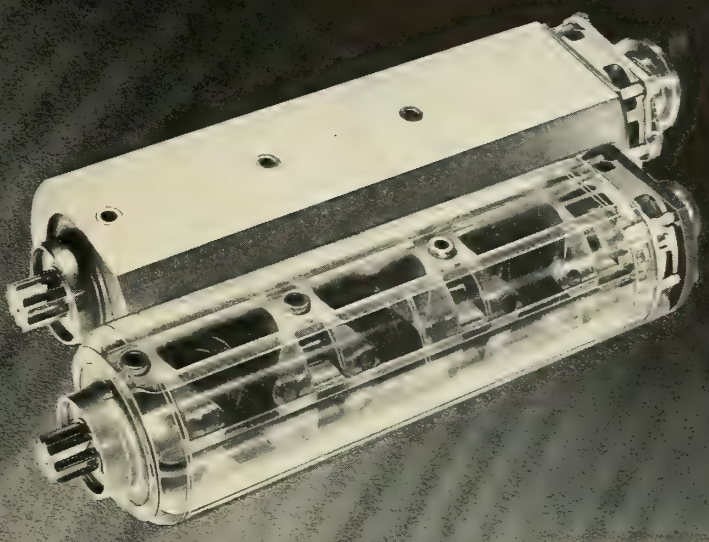
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Max. Dia. Envelope (in.)	4.0	3.2	2.5
Weight (lb.)	22	15.5	7.5
Output at 200 psig supply pressure and 1200 rpm (hp)	18.5	9.1	4.2
Starting Torque at 200 psig supply pressure (inch-pounds)	1800	890	400

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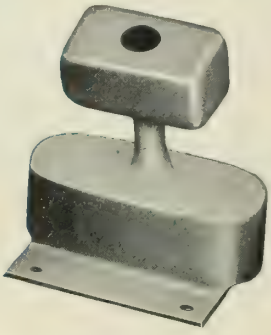
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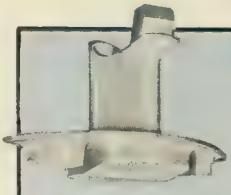
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by the withdrawal of an order eliminating overtime work at Redstone and ABMA.

Many personnel at Redstone feel that former Defense Secretary Wilson never chose to submit repeated requests for additional funds for *Jupiter* and *Vanguard* R&D to the White House. This is why President Eisenhower could publicly state that the missile agencies "got all the money they asked for," because, insofar as the White House knew, all fund requests had been granted.

200-Mile Limit Dead For Army

HUNTSVILLE, Ala.—Former Defense Secretary Wilson's controversial memo of last November 26th, which limited the Army to operational control of missiles with ranges of 200 miles and less, is expected to die an unmourned death before its first anniversary.

Informed sources at Redstone Arsenal and Army Ballistic Missile Agency here are unanimous in their belief that the Wilson memo was made obsolete by the launching of *Sputnik*. One top Army officer declared that even without *Sputnik* it would have lapsed, because of the repeated failures of both Air Force and Navy missiles in the over-200-mile range. He believes the limitation would have been scrapped in actual practice. Tests showed it to be illogical and unworkable because it imposed an arbitrary restriction on weapons whose precise range cannot always be estimated when they are in the research and development stage. It would have proved to be a needless obstacle to the detailed scientific inquiry indispensable to missile and rocket development.

Another informant here said the Wilson memo might never have been issued if the former Secretary had been allowed to retire, as he reportedly wished to do, on last January 1.

"Curley" and Koelle Confuse Missilemen

HUNTSVILLE, Ala.—As if there weren't already enough confusion in missile circles, people at Army Ballistic Missile Agency who telephone Dr. H. H. Koelle, chief of preliminary design, often wind up getting Dr. Wernher von Braun.

The reason lies in a nickname acquired by von Braun and the correct German pronunciation of Koelle's name. Von Braun is known to intimates as "Curley" because of his shock of blond hair. Koelle, in proper German, comes out "Curley" also.

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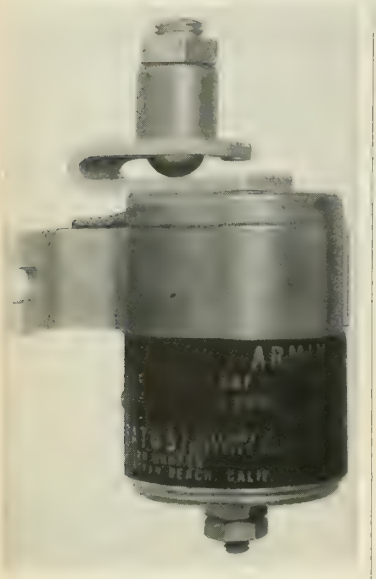
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Missile Arming Solenoid tested at 115,000 ft.



A new arming solenoid, qualified to MIL specifications has been tested at altitudes to 115,000 ft. Designed specifically for arming of a missile on a very high performance fighter, the solenoid can be adapted to other applications. The compact unit weighs only 11 oz., has a normal power drain of 0.7 amps and operates at down to 18 volts. At −65° F and 29 vdc power drain is only 1 amp. Operating temperature range is +250° to −65° F.

While specifications required testing to a lesser altitude, the solenoid was tested at 100,000′ and 115,000′. At 100,000′ altitude 700 RMS 60 cycle current was applied between winding and case for more than a minute. There was no corona discharge, arcing or shorting. At 115,000 feet the test was repeated with voltage being increased at a rate of 25 volts/second. At 825 volts a corona appeared suddenly. Apparently based on electron emission there was no sharply defined path of high conductance. Subsequent retesting of the identical unit showed no damage resulted from the 115,000′ test.

For further information on this high altitude solenoid write to:

STRATOS
A DIVISION OF FAIRCHILD
ENGINE AND AIRPLANE CORPORATION

Western Branch: 1800 Rosecrans Ave., Manhattan Beach, California.

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Sputnik Sparks Reaction at Redstone

SYMPTOMATIC of the mental chaos into which the Russian *Sputnik* plunged the Pentagon, two top U.S. missile experts recently were sharply criticized in official circles for their remarks at the Barcelona sessions of the International Astronautical Federation Congress in October. Redstone Arsenal's commander and deputy commander, Maj. Gen. H. N. Toftoy and Brig. Gen. J. A. Barclay, stated in prepared speeches that the U.S. could have had a successful satellite two years ago. Reaction from Washington was quick and acid. They were, in essence, told to shut up and sit down. The rub: the Pentagon itself had approved both talks prior to the *Sputnik*. But *Sputnik* led newsmen to draw inferences that the Pentagon had not anticipated.

THIOKOL Chemical Corp.'s Redstone Arsenal contract for solid propellants for the *Hawk* short-range missile was reportedly cancelled in late October because of a failure of the solid propellant fuel to bond properly with the metal shell of the firing chamber. Prime contractor for this project was Raytheon. The job was said to have been transferred to Aerojet-General's West Coast branch. Redstone comment questioned whether this was part of an interservice political maneuver to whittle away at the Army's huge missile center in Huntsville, Ala.

"THE THING" is what Redstone Arsenal missileers call the four-stage rocket to be launched in Project *Farside* from a balloon above Eniwetok Atoll in the Pacific within a few weeks in hopes of gaining an altitude of 4000 miles. The assembly is a four-stage rocket. The first two stages consist of five *Recruit* solid-propellant Thiokol engines. Four are in the first stage. Overall length of *The Thing* is 23 feet, weight 1900 pounds. The balloon that is expected to hoist it to 100,000 feet was produced by General Mills Corp.

NO REQUEST from the Navy has been received at Redstone Arsenal for help on the controversial *Vanguard* satellite project, despite repeated assertions by Army officials that the "hardware is available." However, it is learned that a *Polaris* engine is being worked on at Thiokol's plant here, indicating that Navy and Army are at least still talking to each other.

EMPLOYMENT at Redstone Arsenal, Army Ballistic Missile Agency and Ordnance Guided Missile School, all at Huntsville, Ala., now stands at 17,500, including persons working on a $24-million building program. This is up several thousand from last year. Payrolls amounted to $81 million as compared with the county's $60-billion gross income, putting the military in the forefront in this old Alabama area for the first time.

Missile Experts Differ On Crash Progran

HUNTSVILLE, Ala.—Military and civilian experts on rockets and missiles at Redstone Arsenal and Army Ballistic Missile Agency here are sharply divided over a proposed super agency to control research, development and production of missile weapons systems.

The division of opinion follows the kind of clothing worn by the opiner: the military want a crash program; the civilians do not.

This difference is explained by impartial observers on the following basis: The military men are deeply conscious of immediate needs in the event of a sudden war and know the nation is ill-prepared in missile counterweapons. But the civilian scientists believe that potential enemies who might use missiles are actually in about the same state as the United States, in that they may have certain successful prototypes but are still far from full production of IRBM and ICBM weapons.

Another factor is the realization by members of the famous Wernher von Braun team here that one of their number would have little chance of being placed at the head of a superagency with a crash program mission. They are, after all, recently naturalized citizens and have many close relatives in both East and West Germany. They believe their best chance to achieve what they know to be possible in missile research and development would be to work under close and intimate supervision with a board of military and civilian experts who could arrive at well-considered evaluations of specific missile developments.

Kellogg Co. Alumni to Hold Reunion Dinner

Former personnel of the M. W. Kellogg Co. are planning to hold a reunion dinner during the week of the American Rocket Society Convention in New York this December. The dinner's organizers plan to hold it the evening of December 6, at Dido's Restaurant in Bayonne, New Jersey at 7:30 p.m. Reservations may be made with the restaurant at $3.75 per person.



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Magnesium's unique combination of strength and light weight gives it some outstanding abilities as a structural metal. Take rigidity, for example. A magnesium bar has 22% the stiffness of a steel bar of the same dimensions.

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Similarly, a magnesium bar of equal rigidity to an aluminum bar will weigh only 75% as much as the aluminum bar. At equal weight, the magnesium bar will be over twice as stiff.

From these facts it's easy to see that magnesium can do a structural job equal to or better than steel and aluminum—and with appreciable savings in weight—whenever it's practical to increase section thickness. For more information contact the nearest Dow sales office or write to us. THE DOW CHEMICAL COMPANY, Midland, Michigan, Magnesium Department, MA 1402G-1.

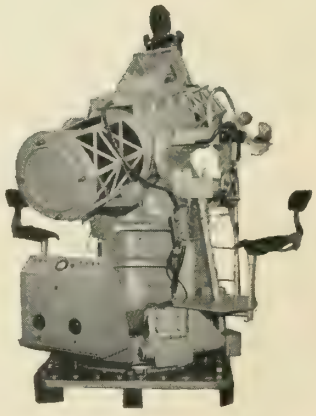
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LOX Plant Developed for Army Front

The Army Corps of Engineers and Air Products, Inc. have developed a million-dollar battlefront plant on wheels for the production of liquid oxygen from common air in sufficient quantity to help power *Redstone* and other missiles. The first of the plants was displayed by the Army at Fort Myer, Va., in late October.

The plant is mounted on four semitrailers and is designed to produce about 20 tons, or about 80 barrels, per 24-hour day of 99.5 per cent pure liquid oxygen when operated at normal atmospheric pressure in air of 50 per cent relative humidity. It will operate in outdoor temperatures ranging from 125°F to −25°F. The plant uses about 920 pounds of diesel fuel per hour and yields about two pounds of liquid oxygen for each pound of diesel fuel.

Two of the trailer units are identical. Each carries a 1200-horsepower diesel engine, and a rotary-type compressor which compresses air to 100-pounds per square inch. There is also an extended-surface heat-exchanger arrangement for cooling the engine and compressor and for a preliminary cooling of the compressed air as it leaves the unit. Each trailer measures 8 by 30 feet, is a little over 11 feet high and weighs about 50,000 pounds.

RMI Rides Out Govt. Economy Wave

Reaction Motors, Inc. has undertaken a program to adjust the company's costs in light of the contract reductions and stretch-outs resulting from the government economy drive. The most immediate effect of the program was a reduction in the firm's work force, but company officials emphasized that no heavy layoff was contemplated at this time.

Even though no actual cancellations of RMI contracts have been received, the company said "certain adjustments are necessary if the company is to maintain its competitive position in the industry."

National-El Ray Co. Forms From Three Companies

A new electronic and electrical component manufacturing firm has been formed by three companies in North Hollywood, Calif. Known as the National-El Ray Co., the new firm is composed of El Ray Motor Co., Valco Engineering Co., and National Electronics Corp.

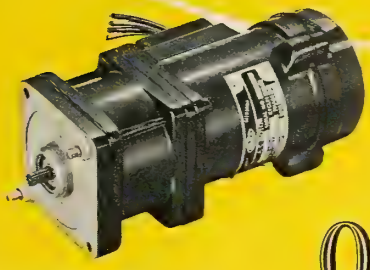
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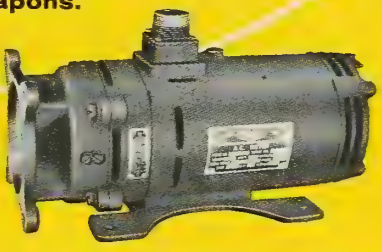
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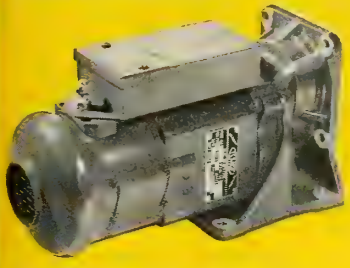


Type: C-1874 400 cycle 3 phase AC Motor and Clutch. **Weight:** 4.5 lbs. **Voltage:** 200 volts. **Output:** 650 watts. **Intermittent duty:** 12,000 rpm. **Meets Military Specification** MIL-M-7969A (ASG).

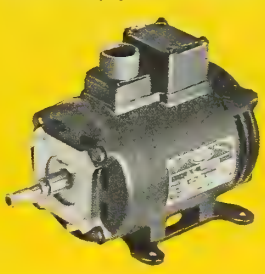


Type: D-638 400 cycle AC Motor. **Weight:** 17.5 lbs. **Voltage:** 200 AC, 20 amps at 6.5 hp. **Duty cycle:** 3.0 seconds at 6.5 hp, 15.0 seconds at 1.5 hp. **Maximum capacity:** 6.5 hp. **Continuous rating:** 5 hp at 2300 rpm, 15.8 amps, 200 volts. **Meets Military Spec.** MIL-M-7969A (ASG).

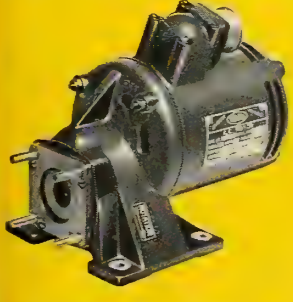
Over the years the precision, ruggedness and reliability of EEMCO products has been proven time and time again. The consistent, exceptional performance of these low-weight, high-output motors, a few of which are illustrated, has earned EEMCO industry-wide recognition. In this highly specialized field, where perfection is imperative, the widespread use of EEMCO motors and of EEMCO's equally reliable actuators is eloquent testimony.



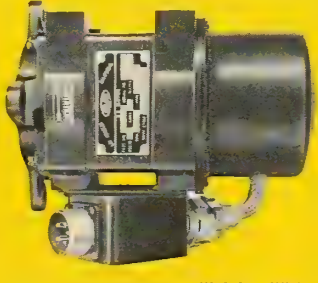
Type: D-751 DC Motor. **Weight:** 20 lbs. **Duty Cycle:** 5.2 hp at 2100 rpm (intermittent) on 26 volts DC; 3.5 hp at 2200 rpm (continuous) on 26 volts DC. **Meets Military Specification** MIL-M-8609.



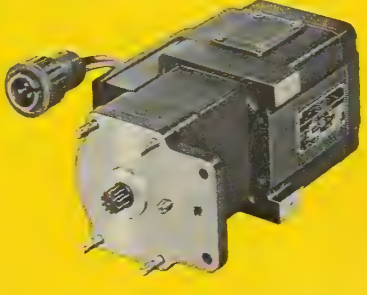
Type: D-800 400 cycle 3 phase AC Motor. **Weight:** 8.75 lbs. **Voltage:** 208 volts. **Horsepower:** 2.5 hp. **Continuous Duty:** 11,300 rpm; Equipped with thermal protector. **Meets Military Specification** MIL-M-7969A (ASG).



Type: D-899 400 cycle 3 phase AC Motor. **Weight:** 11.25 lbs. **Volts:** 200 volts. **Load:** 2.75 hp continuous output. **RPM:** 3140 rpm output at gear box. **Power factor:** 83%. **Overall efficiency:** 76% for entire unit. **Meets Military Specification** MIL-M-7969A (ASG).



Type: D-932 DC Motor. **Weight:** With radio noise filter—13 lbs., without same—12.4 lbs. **Terminal voltage:** 27.5 DC plus or minus 1.5 volts. **Load:** From .5 hp minimum to 2.6 hp maximum. **Speed:** Continuous at 12,000 rpm, plus or minus .005%. **Speed Control:** By frequency regulator supplying control field. **Meets Military Specification** MIL-M-8609 (ASG).



Type: D-927 DC Motor. **Weight:** 7.25 lbs. with 2-circuit noise filter for ungrounded systems. **Weight of filter:** 1 lb. **Terminal voltage:** 27 volts, 18 amps. **Load:** 0.5 hp. **Speed:** Continuous at 9900 rpm. Meets **Military Specification** MIL-8609.

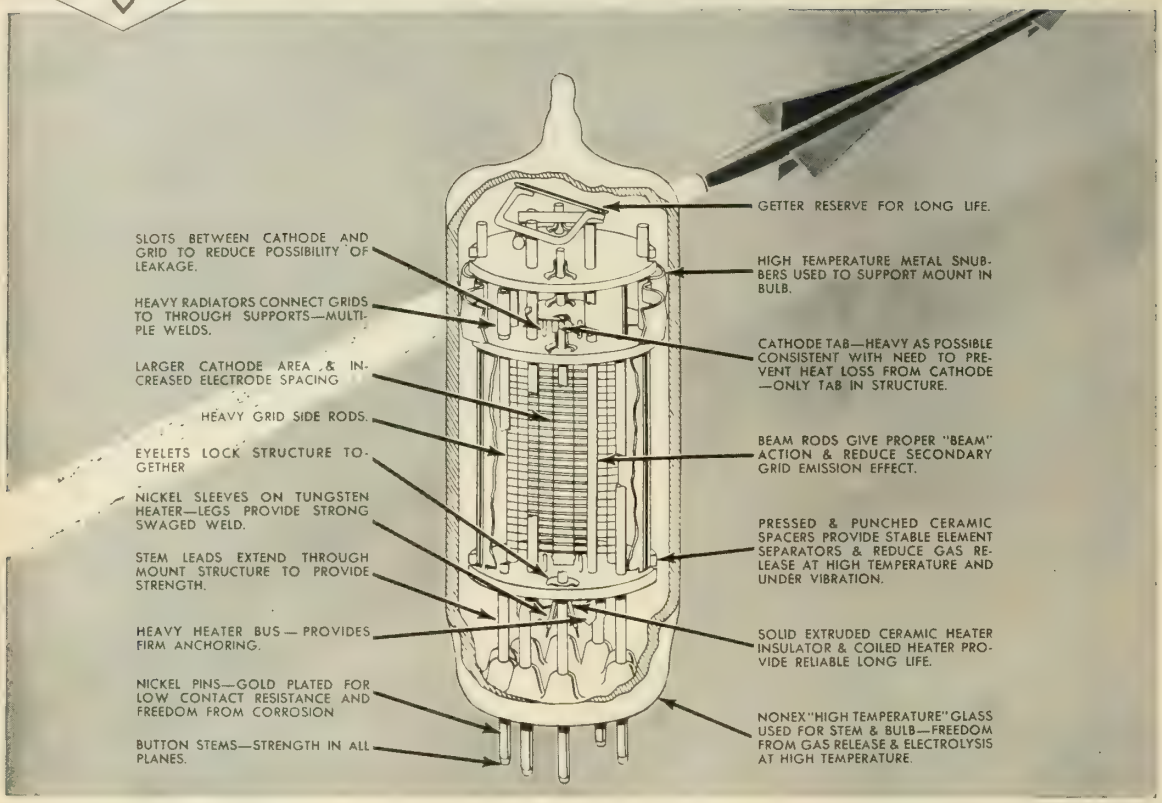
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T-12	—	—	—	—	—	6080WB 6082A
T-11	—	—	—	—	6384 6883	—
T-9	—	—	—	6853	—	—
T-6½	6851 6854 6900	6SH7A	6486A	6754	6094	6877 6900

Retma Type No.	Retrofit For	Generic Type	E_f	I_f	Bulb	Bendix Type No
6080WB	6080 6080WA	6080	6.3	2.5	T-12	TE-46
6094	—	6AQ5-6005	6.3	0.6	T-6½	TE-18
6853	6106 5Y3	5Y3	5.0	1.7	T-9	TE-45
6384	6AR6 6098	6AR6	6.3	1.2	T-11	TE-27
6854	6385	2C51 5670	6.3	0.5	T-6½	TE-47
6486A	6486	6AS6	6.3	0.25	T-6½	TE-43
6582A	6582	6AK5	6.3	0.25	T-6½	TE-44
6754	412A	—	6.3	1.0	T-6½	TE-36
6851	5751	—	6.3	0.5	T-6½	TE-42
6877	—	Half of 6080	6.3	0.8	T-6½	TE-48
6900	5687	5687	6.3	0.9	T-6½	TE-54
6889	—	—	6.3	1.2	T-11	TE-52
6082A	6082	6082	26.5	0.6	T-12	TE-55

Red Bank Division

Bendix AVIATION CORPORATION

Circle No. 38 on Subscriber Service Card.

Scientists Study Spaceship Communication

Studies that might well pave the way for communication with manned spaceships of the future or for the remote guidance of unmanned spaceships is being conducted by Lockheed missile systems division scientists. More than 50 scientists, engineers, and electronic experts will explore the problems of sending and receiving space messages and identifying objects far from earth in a large, new space-communications laboratory.

Emanual A. Blasi, head of the missile division's antenna and propagation department and in charge of the laboratory operation, said areas to be covered include:

The effect of outer space cosmic rays on radar and radio signals.

The radar pattern presented by various space vehicle and missile shapes.

The effect of the ionosphere—the electrically charged space beyond the earth's atmosphere—on such signals.

The characteristics of various antennas when installed in missiles.

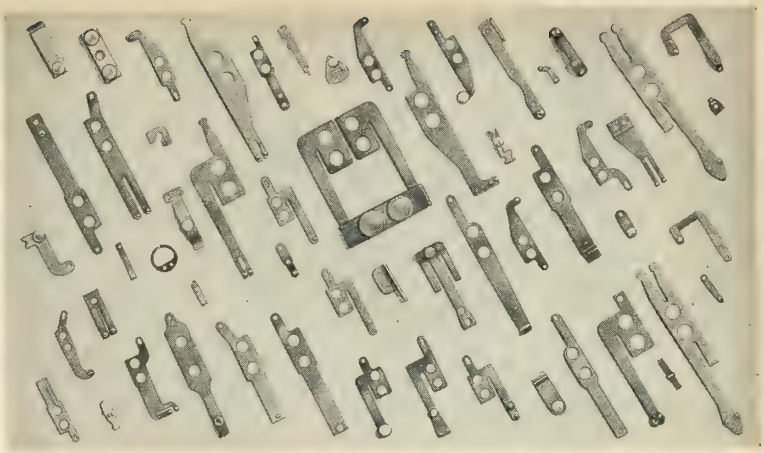
The three-story, 10,000-square-foot laboratory, Blasi said, can recreate space conditions as they exist many hundreds of miles above the earth. An anechoic chamber or "quiet room," measuring 20 by 70 feet, produces electronic conditions to be found 300 miles in space by eliminating all stray electronic signals.

Much of the advance research under way is in connection with the Navy's *Polaris* ballistic missile, on which Lockheed is the missile system manager.

An important part of the investigations covers antenna design and installation. Whether on a missile or spaceship, an antenna will send messages of varying strength depending on its angle to the receiving antenna. Space communication depends on how well the antenna transmits in different positions when installed in a vehicle.

To further these critical studies, the new Lockheed facility has four instrumented antenna and reflectivity ranges with four sets of tracks extending up to 500 feet. Small antennas installed in model missiles are mounted on nonreflecting pylons. Motorized carriages of the pylons, remotely handled from control rooms, carry the models to various distances along eight-foot tracks for the tests.

Because of the intense interest and research in space communications, the Lockheed facility will be made available to other scientific groups on a commercial basis.



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Tricon furnishes contact assemblies to the electro-mechanical industry and specializes in missile control applications. At Tricon you have a team of specialists in the manufacture of switch and relay spring-blade components, as well as precious metal contacts and assemblies.

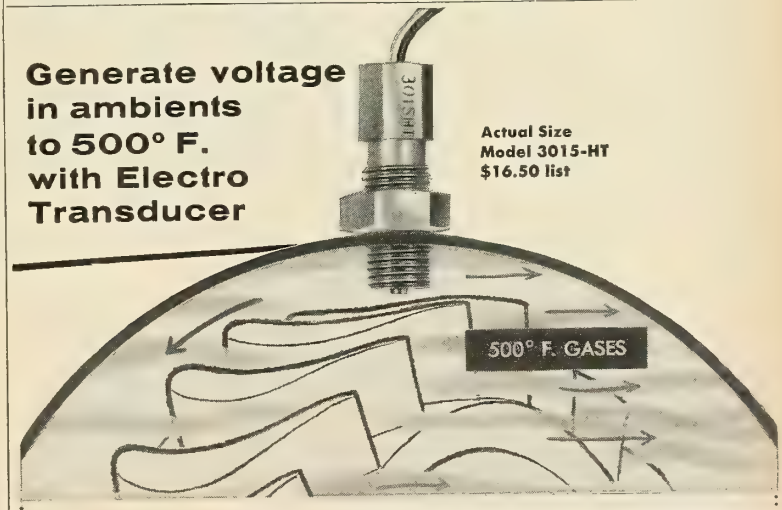
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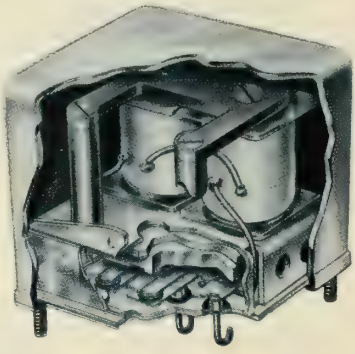
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These Leach Relays meet or exceed requirements of MIL-R-5757, MIL-R-6106, MIL-E-5272. Typical ratings include: vibration, 20 G's to 500 cps (higher ratings available); shock and acceleration, more than 50 G's; temperature, −50° to +125°C; life, 50,000 continuous operations minimum at rated load; available 28 vac, 115 vac, 400 cps operation. At right is Leach 9226, 1.49x1.49x 1.68 inches.



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Russian Public Watch Their *Sputniks*



Moscow moon watchers on the lookout for SPUTNIK I and II. Next: they will be looking toward the moon . . .

Narmco Facilities Increased by 20%

Narmco Mfg. Co.'s completion of plant No. 2 in La Mesa, Calif., adds 20% to the firm's manufacturing capacity. The one-story concrete block building houses expanded tooling, assembly, inspection and shipping facilities for the production of glass fiber laminates and sandwich-type structural components for aircraft and missiles. Narmco's backlog of orders of components and assemblies has increased 200% in the past 18 months.

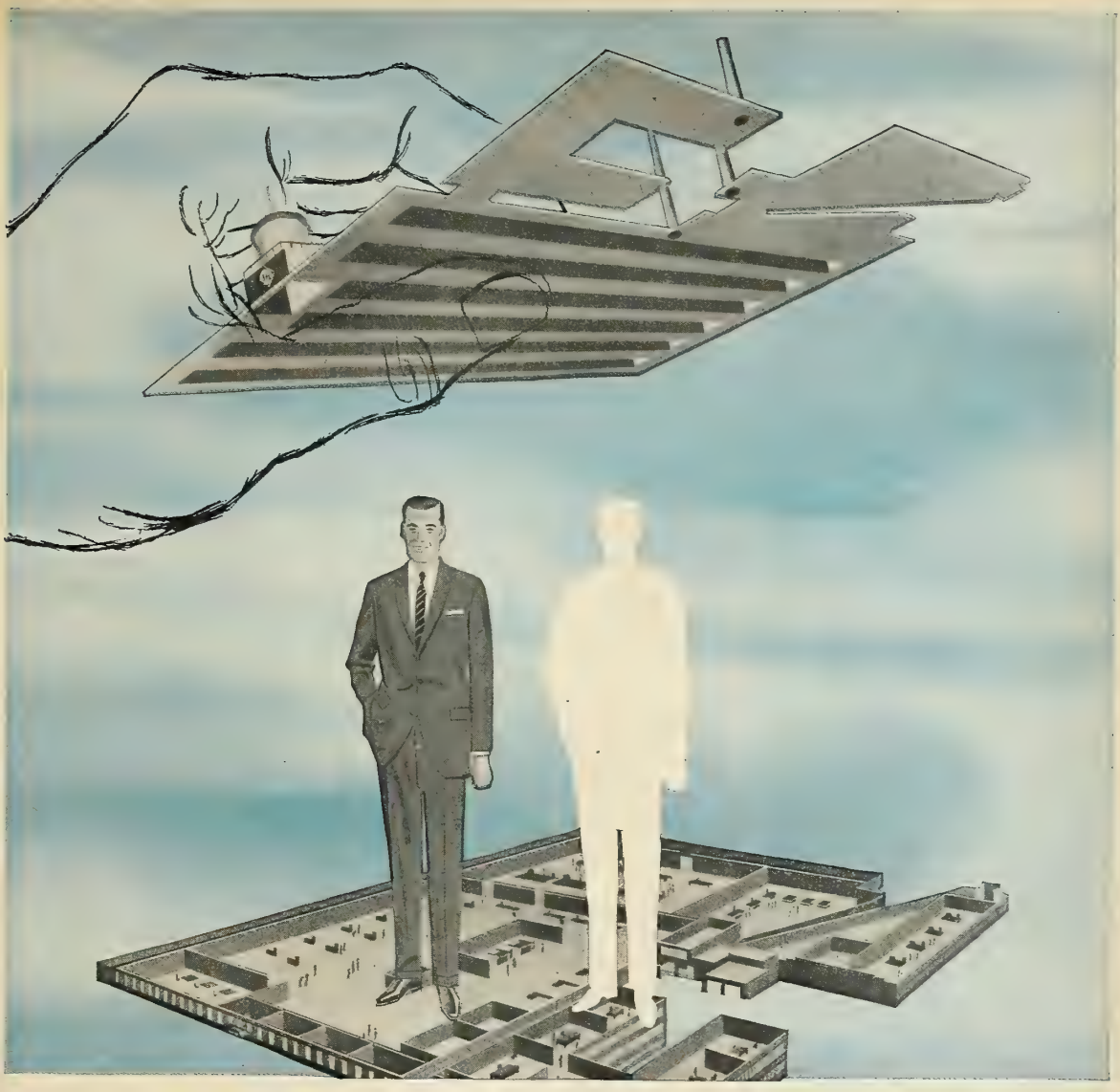
R & D Program Begun By Synthetic Lithium

A joint program of research and development involving the Lithium Corp. of America and the Synthetic Mica Corp. has begun for the study of a new electronic tool—synthetic lithium flour-phlogopite mica. The new product is reportedly far superior to its potassium counterpart currently produced by Synthetic Mica Corp. Lithium Corp. will produce the lithium compounds necessary for production.

Lear Supplies *Bomarc* Guidance Parts

Lear, Inc., is producing airborne electronic intelligence components that control and direct the *Bomarc* interceptor missile to its target.

Although the Air Force does not identify specific components, Lear is known to be a producer of master references, stable platforms, computers, data links, and gyroscopic devices for automatic flight stabilization of guided missiles.



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When you invite us to develop and produce aircraft systems or equipment, we immediately assign a top man to get you what you want and need.

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We invite your inquiry. Write Jack & Heintz, Inc., 17637 Broadway, Cleveland 1, Ohio.

JACK & HEINTZ AIRCRAFT SYSTEMS AND EQUIPMENT



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New Liquid Rocket Engine Design Shown

An integral, self-contained liquid propellant rocket engine package was shown publicly for the first time today by Reaction Motors, Inc. The powerplant as delivered includes the entire engine system, complete from propellants to thrust chamber. It is designed to be delivered ready to be fired upon installation in the airframe.

All propellant loading is done before the unit leaves the factory so that no propellant handling is required in the field. According to RMI spokesmen, the unit can be stored in a remote location for years, and installed at the time the airframe is to be launched. Its reliability is said to be extremely high.

RMI has plans for developing the unit in a wide range of sizes and performance specifications for use in most of our current and forthcoming missiles. Flexibility in operational characteristics—choice of propellants, duration of firing, thrust level—is one of the unit's main features.

GE Fuzing Army Missiles

The Army has disclosed that General Electric is working on multi-million-dollar projects to develop warhead arming and fuzing systems for five Army missiles.

GE's missile and ordnance systems department in Philadelphia is working on or has recently completed arming and fuzing system projects for the Army's *Honest John, Little John, Corporal* and *Lacrosse* surface-to-surface missiles and on the Army's *Nike-Hercules* surface-to-air missile.

It was previously known that GE had received Army contracts for guided missile arming and fuzing development, but the full extent of the work was not disclosed until recently.

New Monopropellant Licensed to Thompson

A new heterogeneous liquid monopropellant developed by Atlantic Research Corp. has been licensed to Thompson Products, Inc. The exclusive right to purchase, use, and sell the new propellant, called Arcogel, was conveyed to Thompson by a licensing agreement. The agreement includes a royalty to Atlantic Research on future sales of the gel propellant and burner systems. Thompson Products has also given a $30,000 contract to Atlantic Research to continue development of the propellant and associated burner systems.

Use of the new substance in both gas-generating and propulsive applications is being contemplated by Thompson. Refinement of manufacturing techniques, new formulations of the gel propellant for specific applications, and development of burning systems will concern Atlantic Research scientists, engineers and technicians.

Anti-Missile Office Opens at Redstone

HUNTSVILLE, Ala.—A new facet of missile activity will begin here shortly with the opening of the Redstone Anti-missile Missile Systems Office, marking the beginning of a concentrated effort to develop the so-called "ultimate weapon" to counter ICBMs.

The new office, already condensed to RAMMSO in official terminology, will be set up with a cadre of experienced scientists and technicians from Redstone Arsenal and Army Ballistic Missile Agency and is expected to be functioning by mid-November.

One of its first projects is reported to be a faster, more accurate version of the *Nike-Zeus* missile. This is regarded as a logical first step toward development of a program to offset Russia's presumed capacity to begin ICBM production within the near future.

Establishment of the RAMMSO office was hailed here as an indication that the work of Dr. Wernher von Braun and his Army missile team has gained recognition in the wake of the accelerated missile research and development programs authorized by the new Secretary of Defense, Neil H. McElroy.

No formal announcement of the RAMMSO office has been made here but informed sources said financial support has been guaranteed and a table or organization authorized.

The basic mission of the new office will be to coordinate all military and industrial activity required for the production of the anti-missile missile.

Technique Associates Move to New Quarters

Technique Associates, Inc., manufacturers of temperature measuring and indicating instruments, has moved its general offices and plant to larger quarters at 1413 N. Cornell Avenue, Indianapolis, Ind. Mailing address of the company is P.O. Box 91, Indianapolis, Ind.

Washington Trends

By Erik Bergaust



DEFENSE SPENDING WILL RISE SHARPLY IN THE NEAR FUTURE, with most emphasis on R&D phases of missiles. With almost all research fund cuts of recent months being restored after *Sputnik* I, the Capitol Hill fur will really fly soon after November 7, if the Soviet attempt at launching something spectacular is a success. The Reds are certain to try to mark their 40th anniversary "in a most fitting manner," as the pre-*Sputnik* statement said. If, as we believe, the Reds will try for a grandstand play on that date, they could not have better cooperation from the moon. It will be a full moon—with a full eclipse. With perfect timing and guidance, a flash bomb on the moon at this time would have a hundred times more effect than *Sputnik* I. And even though this is not considered likely, who (after *Sputnik* I) will stand up and say the Reds can't do it? The Naval Observatory here says the eclipse will be visible in the western half of North America and across the Pacific to Asia. An excellent audience.

DEFENSE CUTS HAVE LEFT THEIR MARK. Due to the slashing of defense expenditures, the top-secret Lincoln Laboratories in Lexington, Mass., has been forced to announce the dismissal, as of February 1, of 160 of its personnel, many of them scientists and engineers. The breaking up of such a team is much more damaging than the layoff of a much larger number of production workers.

EDUCATION MUST BE RECOGNIZED AS THE PRIME ASSET OF THIS COUNTRY. The President's Committee on Scientists and Engineers here has been told that the 14-year-old boys of today will be the designers of our rockets and satellites in just ten short years. Nevertheless, there is not a school in the country offering a curriculum in rocket design. The American Rocket Society accepts student members only when they are 17 years old. By this time, a boy is practically an engineering student and has not had the benefit of pre-college counsel in the rocketry field.

CODE NAME FOR ARMY'S SATELLITE IS "DEAL." IT HAS PENTAGON GO-AHEAD. The program will be taken in steps. *Jupiter-C* can orbit 18 lbs. It's based on *Redstone* first stage. By replacing *Redstone* with *Thor/Jupiter* first stage and using *Sergeants* as second stage, it could conceivably place 1000 lbs. in an orbit within a few months. This program is in sharp contrast to an earlier Wilson order that Army would not work on satellites nor admit that Army interest in satellites existed. At one point, Assistant Defense Secretary McNeil dispached auditing teams to ABMA to ascertain that Army was obeying the order. This was BEFORE *Sputnik* I.

TESTS OF THE *RASCAL* WERE FROM MAXIMUM RANGE OF 100 MILES. Bell Aircraft confirms that the missile was fired from the limit.

THE AIR FORCE HAS A NEW WIND TUNNEL that duplicates "far-hypersonic" conditions, enabling scientists to study the high pressures, velocities and temperatures encountered by a missile re-entering the atmosphere. It can also duplicate the real gas effects of high-speed missiles operating in the atmosphere.

ONE OF ATOMIC ENERGY COMMISSION'S BIGGEST HEADACHES is the disposal of "hot nuclear garbage" which has been costing John Q. Taxpayer millions of dollars. It can't be disposed of, but must be stored in expensive stainless steel tanks and transferred to new tanks as it eats its way through the old ones. Rapid advance of rocket technology may provide the answer. Within 20 years, some experts estimate, it may be cheaper to load the stuff into rocket vehicles and impact it on the sun! The idea doesn't exactly intrigue us.

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Soviet Affairs

by Dr. Albert Parry

It is with sad pride that this column takes credit for a major prediction come true: In my first column last July, I cited as worthwhile the conviction of an émigré source that the Reds would fire their artificial satellite into outer space on or about Sept. 17th, to celebrate the 100th anniversary of the birth of Constantin Tsiolkovsky, a Russian rocket pioneer. I referred to the forecast as an "educated guess." The Soviets fired their moon on Oct. 4th, making the prediction only two-and-a-half weeks off its mark.

•

And now let me cite one more Russian prediction, this time not from émigré quarters but from a Red source, a prediction published in Leningrad nearly 30 years ago—that rockets and death rays will be used by the Soviets to defeat the United States in a future war between the two nations. This bold prophecy was made in a government publication. It was a book of science fiction, BOR'BA V EFIRE (STRUGGLE IN THE AIR), by Aleksandr Beliayev, issued in 1928 by the Communist Youth League publishing house with the approval and under the auspices of the Soviet state itself.

•

That 1928 fantasy is startling and revealing, yet it is rare in the sense that the book came out in a small edition and, to my knowledge, has not been reprinted in Russian or translated into any other tongue. Its export from the Soviet Union was not encouraged by the Kremlin. In all my diligent, protracted search I have to date succeeded in locating only two copies of this book (in its Russian original) in this country.

•

Why so scarce and obscure? The reason may be that the Soviets might have had second thoughts about the book soon after its publication. The frank story tipped the Red hand too early in the long-range timetable of America's destruction. At that time, in the latter 1920s, the Kremlin wanted American aid in Russian industrialization. It also wanted our recognition of the Soviet government. And so the daring book, although commissioned by the government, was practically "closeted" by the very same Red government.

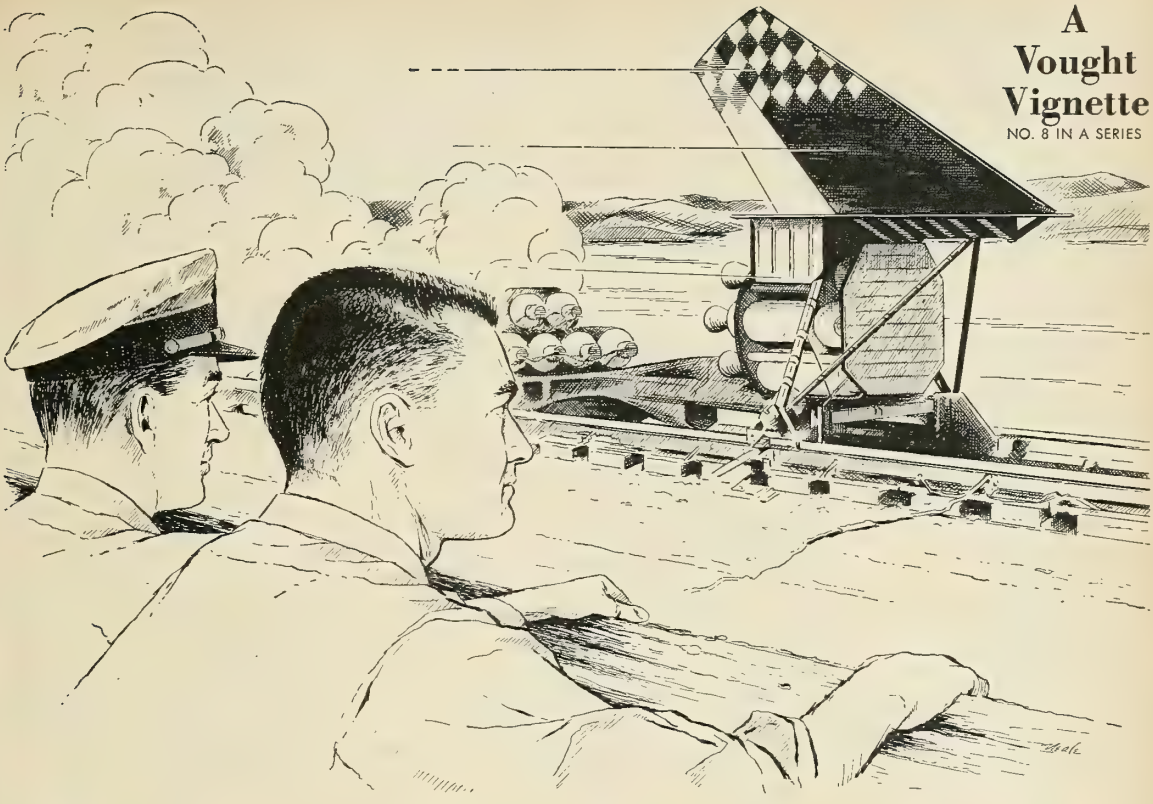
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Yet consider the time and the setting of that old Soviet prophecy. Three decades ago, while Red Russia was feeble and seemingly knew not which way to turn in order to survive, and while we were at the height of our Coolidge-era prosperity and power, the ruling class of the Soviet Union had this arrogant confidence that America and the rest of the West were doomed—that the "bloated capitalists" would perish through the coming Red might of rockets and rays to be delivered against New York and Washington by air, the weapons already then theorized by the little, aging provincial teacher of high school physics and mathematics, Constantin Tsiolkovsky of Kaluga, and his vigorous Soviet followers.

•

Truly no greater service toward awakening America from her complacency can be performed by some American publisher than through publishing this 1928 novel by Beliayev in English.

A Vought Vignette
NO. 8 IN A SERIES



The structures engineer who found a fast detour

"Advise and assist on structural problems. Do what you can to keep the program moving . . ." With this outline of his liaison duties, Stress Analyst Ed Clay accompanied Vought's Regulus II missile to its desert test site.

On the desert, Ed found a dearth of structural problems. Regulus II reliability gave the flight test program tremendous momentum. In quick succession the missile notched 10 flights. When time came for a critical high-speed test, the program was three months ahead of schedule!

Then, the very fact that things had moved so fast threatened to rob the program of the time it had gained.

As Vought had planned, a wind tunnel flutter test had to precede the upcoming high-speed flight. But Vought's prearranged date at a government tunnel was over a month away. The facility was booked solidly up to the appointed day. And Vought's own Mach 5 tunnel was under construction.

Then Ed revealed the scope of his liaison. It had ranged to the rocket test track at nearby Edwards Air Force Base. There, with the help of a cooperative track project engineer, Ed had spotted a rusting rocket sled, left behind from a radome test. Now, if the sled could be rigged to carry that spare Regulus fin, Ed figured, they might get flutter data before the tunnel test.

That changed Ed's state of liaison. All Vought was suddenly at *his* service. Shopmen reworked the sled to mount the fin. Instrumentation technicians fitted the fin with gages and transducers. Vought's top flutter men double-checked, raised their eyebrows, then endorsed the whole thing.

At the track, moments before the rockets exploded, Ed had a twinge of doubt. His sled was a monster, indeed. Air loads would be terrific . . .

Then the sled shot off on the first of two successful trips that revealed all the data required.

At Chance Vought, there's liaison in spirit as well as in name. It allies engineers of many specialties and viewpoints against mutual problems. It builds channels instead of walls between diverse technical areas. It's another reason why top engineers are choosing Vought — *to keep abreast of all fields while advancing in one.*

CHANCE VOUGHT AIRCRAFT
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World Astronautics



By Frederick C. Durant III

A resolution to establish a Joint Committee on Earth Satellites and the Problems of Outer Space has been introduced by Rep. James G. Fulton (R-Pa.). This bill, currently referred to the Committee on Rules, has a great potential for bringing to the attention of Congress and the public the ramifications of extended satellite programs. The bill as it now reads calls for full and current briefing by the DOD on "all matters . . . relating to the fields of earth satellites and outer space." It goes on to state that, "any Government agency shall furnish any information requested by the Joint Committee with respect to such activities or responsibilities" and that, "all bills, resolutions or other matters relating primarily to the development, use or control of the earth satellites and outer space shall be referred to this Committee." Truly, this Committee would have great potential influence in the development of astronautics, particularly during the next few years.

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Original reports attributing the origin of the delightful "Geschutenwerkes Werdebuke" (m/r September, p. 54) to ABMA have not been verified. Two key technical members of the ABMA staff were delighted to obtain copies recently. Former German nationals, they commented privately that they had not seen it before. The author is probably a native born American. He deserves credit for a charming bit of whimsy and we would like to see him identified. Incidentally, a few copies of the complete list of translations of 43 terms are available on request to this column.

•

The Associacion Argentina Interplanetaria (AIA) has expanded their rockets and satellites course. Ing. T. M. Tabanera, AIA president, has organized the course which is being held at the Sciences Faculty of the University of Buenos Aires in collaboration with the Institute of Scientific Research on Weapons. The course is in five parts: rocket motor design, energy sources, ballistics and guidance, electronics and hypersonic aerodynamics. The course runs three and one-half months.

•

Preliminary meetings toward the forming of a Korean Astronautical Society have been held during the past few months in Seoul. Byung June Chang has attracted the support of local university professors and has requested registration by the Ministry of Education.

•

Niichi Nishiwaki, professor of mechanical engineering at the University of Tokyo, has completed a year as visiting professor at MIT. While in Cambridge he conducted basic research in combustion problems. He returns to Tokyo via Europe where he will visit a number of aviation and rocket propulsion establishments. Prof. Nishiwaki is active in both the Japanese Rocket Society and the Japanese Astronautical Society.

•

At the Annual Meeting of the Deutsche Arbeitsgemeinschaft für Raketentechnik (DAFRA) last month, President A. F. Staats announced the grant by the city of Bremen of DM5,000 to the Society for their experimental work. This significant sum is in addition to contributions by numerous industrial concerns. While there I saw motion pictures of the August firings of sounding rockets at Cuxhaven. Only a tantalizing glimpse was given of two larger two-staged prototypes which have yet to be tested.

Manufacturing at Marquardt



by
Roy E. Marquardt
President

Another barrier — the PRODUCIBILITY BARRIER — is currently being penetrated by Marquardt engineers. What do we mean by PRODUCIBILITY BARRIER?

Advanced designs for supersonic ramjet powerplants coming from the drawing boards call for strength to weight ratios and high-precision tolerances previously unobtainable. New high-temperature alloys are meeting the metallurgical demands, but do not readily lend themselves to conventional machining and fabricating techniques.

Those members of the Marquardt team charged with pioneering new production methods comprise our Van Nuys Manufacturing Division. Here — under the direction of John S. Liefeld — creativeness and imagination join forces with a thorough understanding of standard shop practices to produce acceptable hardware. But management realizes that to do his best work the engineer must be supplied with the most up-to-date tools of his trade.

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Roy E Marquardt

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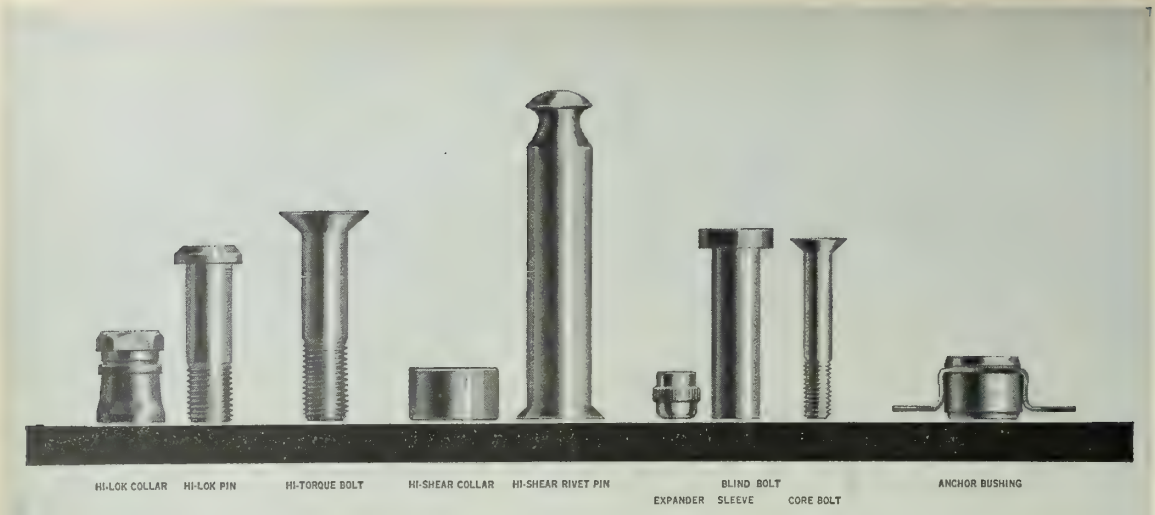


Shown here: John S. Liefeld, Director Van Nuys Manufacturing Division

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VOL. 2 NO. 11

NOVEMBER, 1957

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

an m/r analysis:

Law Must Precede Man Into Space

By Andrew G. Haley

President, International Astronautical Society

NEVER BEFORE in the history of mankind has the necessity arisen so quickly to state legal parameters in connection with a vast new area of social change. The legal problems presented by the advent of space flight have been climacteric, and technology has far outstripped the formulation of the legal rules. The gap has widened to the point that the peace of the world is threatened.

The consent of all nations to the satellite program of the International Geophysical Year and the active cooperation of most nations have resulted under familiar and accepted principles of international law in giving full legal validity to the present IGY satellite program. But this is the one and only achievement. Space law still completely awaits development.

The most unfortunate development in connection with the orderly statement of space law has been the involvement of the problem in the proceedings of the United Nations Subcommittee on Disarmament in London. This involvement was inevitable because the question of control of objects entering outer space was bound to arise. The problems of space law found their first and most critical examination in the intense political atmosphere of the London Disarmament Conference. The statement of space law problems and the formulation of jurisdictional concepts and regulatory rules should long since have been undertaken by appropriate juridical bodies of the United Nations and of the International Civil Aviation Organization.

In arriving at a level-headed statement of the jurisdiction of space law, the lawyer must turn for help to the physicist to ascertain just where "air space" ends. We must ascertain the outer boundary of air space because hundreds of local laws of more than 90 nations and restrictions of a score of international treaties are bound tightly by the physical concept of air space.

Ironically enough the lawyer finds the main crackpots and nuisances among engineers and sociologists who assume the role of amateur lawyers and give vent to rather silly if harmless rhapsodies in a field wholly unfamiliar to them. To them the real problem of delimiting air space is wholly unnecessary. The sound scientist avoids legal interpretation, while at the same time making essential contributions by staying within his technical expertise, and keeping the lawyer well-advised on appropriate physical phenomena. Such has been the most helpful role of Dr. Theodore von Karman.

Dr. von Karman has suggested practical methods of formulating the jurisdiction of air space. Last spring he delivered a paper at the University of California entitled "Aerodynamic Heating—the Temperature Barrier in Aeronautics." In that paper he had occasion to use a diagram made by Masson and Gazley of The Rand Corporation showing the possible ranges for continuous flight in the velocity-altitude coordinate systems.

Pursuant to von Karman's suggestion I devised a diagram (Fig. 1) containing curves showing the high-altitude sounding rocket regime, the earth orbital satellite regime and the Kepler regime (earth escape velocity) and some supernumerary information. But most important is what we shall now call the Karman primary jurisdiction line.

To establish sound bases for demarcation of air and space jurisdiction, it is necessary to consider that the conditions for achieving aerial flight, that is to circle at constant altitude, are that weight equals aerodynamic lift plus centrifugal force.

The aerodynamic lift decreases with altitude because of the decreasing density of the air and in order to maintain continued flight beyond zero air lift, centrifugal force must take over. Consider the flight of Captain Ivan C. Kincheloe, in which he took the X-2 rocket plane to 126,000 feet altitude. His flight was strictly an aeronautical adventure and did not partake of space flight. At the altitude indicated, aerodynamic lift carries 98 per cent of the weight and only two per cent is centrifugal force, or "Kepler force." It will be noted that in the corridor of continuous flight when an object reaches approximately 275,000 feet and is traveling at 25,000 feet per second, the Kepler force takes over and aerodynamic lift is gone. This is a critical jurisdictional boundary.

Fig. 1 is intended to be illustrative. The Karman line may eventually actually remain as shown in Fig. 1 or, after due consideration, the line may be significantly changed. In any event, this is the line at which "air space" terminates.

Any such definition should be finally promulgated through the United Nations and implemented by the In-

ternational Civil Aviation Organization (ICAO). In determining the Karman line, the United Nations and ICAO will require the advice of a committee in stating the final definitions and in drafting detailed regulations. The basic statutes of ICAO will have to be broadened by international agreement and the name undoubtedly must be changed.

The first important action taken so far was the establishment in Barcelona by the International Astronautical Federation of the Cooper Committee, headed by world-renowned Professor John Cobb Cooper. It will consist of three lawyers and four physicists who will define air space and space jurisdiction.

It would be senseless to build a surface transatlantic steamship to perform the undersea functions of a submarine. The functions of the aircraft and the rocket ship are essentially even more disparate. In arriving at a reasonable Karman line, physicists and lawyers inevitably will reach agreement as to the point where the aeronautical vehicle no longer may perform efficiently and within reasonable physical and engineering parameters. It may be useful to examine, momentarily, some of these parameters:

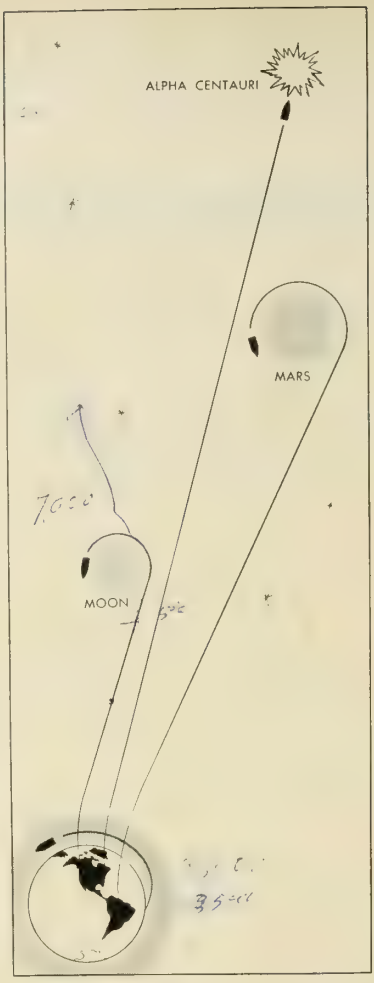
A. M. Mayo has pointed out that control of the pilot's immediate environment from the standpoint of pressure and composition would become increasingly difficult as a function both of the length of time of flight and of the pressure reduction and change of atmospheric composition.

He goes on to state that at altitudes below approximately 70,000 feet the problem of pressurization and composition is taken care of relatively easily by pressurizing outside air. At higher altitudes, pressurization of outside air becomes increasingly difficult both from the standpoint of the power required and from that of handling the very high temperatures resulting from extreme ratios.

Many other considerations will enter into the final determination of the Karman line. The danger of material collisions with the airframe, escape problems, the problems posed by combined stresses and multifold fundamental questions of the construction of aircraft, as such, will all enter into the final decision.

H. Strughold points out that with increasing altitudes, some of the biological effects creep in gradually, while others rise at sharply defined levels. On the whole, the road from the surface of the earth to free space displays characteristic ecological stages. These stages are determined by the functions which the atmosphere has for man and craft.

He points out that we must first consider the oxygen component in the chemical constitution of the air. In this respect, only the lower half of the troposphere can be designated as the physiological atmosphere or the ecosphere of the air. It is in this narrow zone that the stage for the drama of life on our planet is normally set. Only this layer deserves the name "atmosphere," which, from the Greek "atmos," means "breath."



The above sketch illustrates the four basic jurisdictional regimes: (1) the earth's shaded area shows the Karman primary jurisdictional line delimiting the air space; (2) the lunar orbit delimits the Keppler regime of earth; (3) the Martian orbit illustrates the solar Keppler regime which ends at a point beyond Pluto; (4) the Alpha Centauri trajectory is one illustration of the Sänger regime.

E. O. Hulbert states that the region of the atmosphere from 0 to 6.2 miles, where the temperature falls rapidly with increase of altitude, has long been called the troposphere. The region from 33,000 to 66,000 feet, where the temperature is approximately constant, is called the stratosphere.

The ionosphere has its own well-accepted nomenclature, the terms D, E, F_1 and F_2 designating the four ionized regions with maxima of ionization at about 43.5, 62.1, 124.3 and 186.4 miles respectively. Aside from these, there is no generally accepted terminology of upper atmospheric regions.

The terms upper and outer atmosphere are used with different meanings depending on the context, and it is best to keep their meanings fairly elastic. The region from about 12.4 to 21.7 miles, which embraces most of the ozone, has been called the ozone layer or ozonosphere. It has been proposed that the region from the top of the stratosphere, at about 12.4 miles, to the minimum of temperature, at about 43.5 miles, be called the mesosphere and the region of increasing temperature, somewhere above 62.1 miles, the thermosphere.

The exosphere has been used to refer to the outer fringe of the atmosphere, where the air particles execute long elliptical orbits bouncing outward from impacts with other particles and falling back under gravity. In general, Hulburt concludes, the physical properties of the various regions are not yet well enough known to permit their fixation by an accepted terminology.

In their most recent writings, Cooper and Meyer have sought to locate air space jurisdiction at a point in the ocean of air surrounding the earth where aerodynamic lift is gone. These authorities have avoided the mistakes of engineers and sociologists suddenly turned amateur lawyers, who are attempting to locate air space jurisdiction in such heterodox and altogether eclectic regions as the thermosphere, exosphere, mesosphere and ozonosphere, even the nomenclature of which is doubtful, and none of which has any reference whatsoever to the problem at hand.

Under certain conditions national jurisdiction will be *quite indirectly* but effectively maintained over what is called by Professor Cooper "contiguous space." In the near future the nations of the earth will be offered point-to-point rocket communications involving many services.

The trajectories of each of these routes will be different, and will involve different altitudes. Some of these rockets will describe a trajectory requiring heights of 300 miles or less, and others will probably require heights in excess of 1000 miles. National jurisdiction will be effectively maintained by the granting of launching and landing rights, and thus there will be indirect national control with respect to point-to-point earth rockets over contiguous space.

The international regulation of

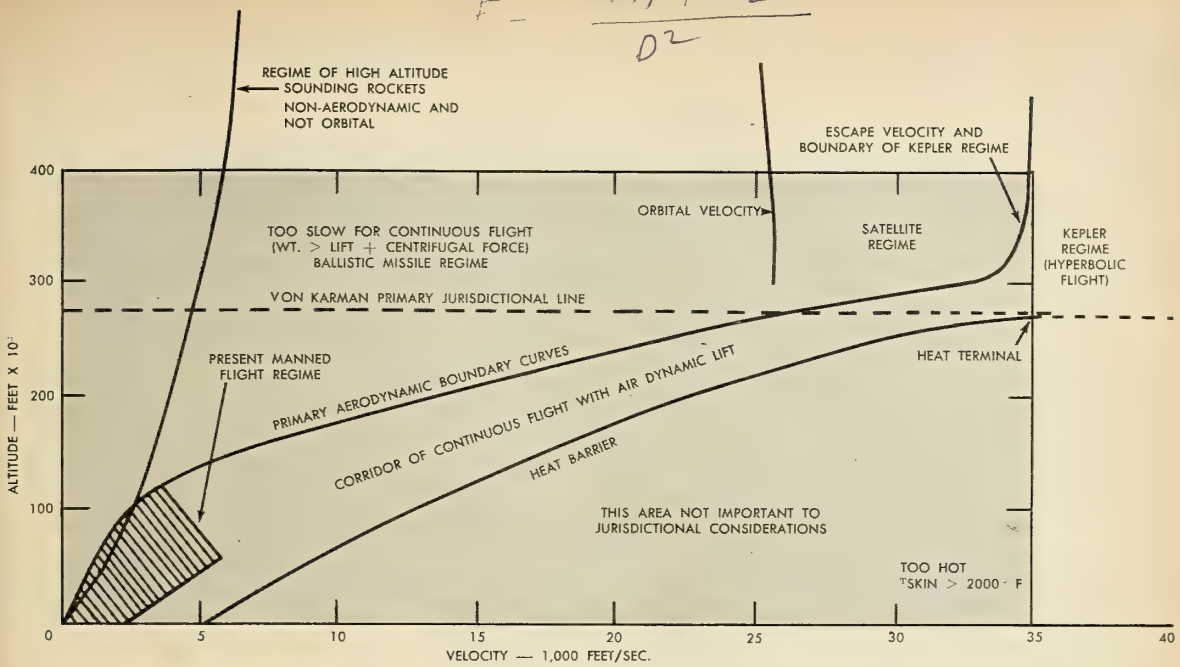


Diagram showing regimes of atmospheric and extra-atmospheric flight and depicting jurisdictional boundary lines.

point-to-point earth rocket vehicles will be under the jurisdiction of a successor international governmental organization to ICAO. The very problems of locating instrumentation along the manifold aerodynamic and nonaerodynamic routes, orbits and trajectories will require the highest degree of international cooperation and regulation for the operational efficiency and safety of all concerned.

The aircraft, the point-to-point earth rocket ship, and the spaceship capable of freely maneuvering in outer space when navigating around earth or landing on earth, will each need navigation aids, anticollision devices, secondary radar, communications systems, meteorological services and many other international aids and services. In every instance of movement to or from any point on earth, the national licenses and permits which are the essential prerequisites of national society will be needed.

Mankind must mature appreciably to create an international authority having sole and complete jurisdiction over space flight and such an achievement must wait the wise action of future generations.

No single nation has a paramount claim to outer space nor a monopoly on the scientific genius which will soon make its exploration and exploitation a reality. The field of astronautics will progress only as international cooperation in the field is achieved.

National sovereignty ends for all purposes with the Karman line. By way of analogy, the Stephen Decatur Doctrine demonstrated 150 years ago, that:

> The seas beyond reasonable coastal areas [space beyond the Karman line] are free and subject to control by no single despot or nation, and
>
> The sponsors of ships at sea [spaceships in space] must be responsible for the conduct of their vessels.

More than 50 nations are participating in the IGY. This involves very extensive utilization of governmental and nongovernmental facilities and personnel. Active participation in the program is required of each nation, of its army, navy, air force and coast guard personnel and facilities; of such governmental agencies as those concerned with standards, radar, radio, meteorology, weather, coast and geodetic surveys, geological surveys, and all types of official scientific and research organizations.

In addition, parallel, nonofficial institutions are involved, including universities and observatories in those few countries where such institutions are not controlled by the state. By agreeing to support actively the satellite program, the foregoing nations also agreed to the legal validity of the project.

On the basis of sound principles of international law, the nations of the world may not protest the flight of a nonmilitary artificial satellite over their territories when the purpose of such flight is the accumulation and dissemination of scientific data which shall be made available without restriction to all the nations of the world.

No single formal treaty emerged from the myriad agreements involved in the IGY. Nevertheless, a valid and binding world pact emerged from these acts of agreement and cooperation.

The international pact, in written form, may be abstracted from the thousands of documents and exchanges from which the living IGY has evolved. There is nothing about a single formal treaty which makes it sacrosanct or makes it even an essential source of international law.

In many instances the principles set forth in the treaty itself may have been established in international law long prior to the signing of the formal document itself. A rule of international law does not receive its validity from its enactment into a legal instrument, such as does an international law, which is valid although not enacted in such legal instruments. There are rules of international law which are not valid, although enacted in such instruments. Enactment, therefore, is no objective criterion for the alleged validity of a rule of international law.

The social scientist, just as clearly as the natural scientist, has the duty to acquire base-line data and then to implement such data in the dynamic evolution of society. The advent of the rocket motor, with its potential of unlimited access on the earth and in space, presents a great new mutation requiring the immediate and careful attention of the social and natural scientists. The base-line material of the law-

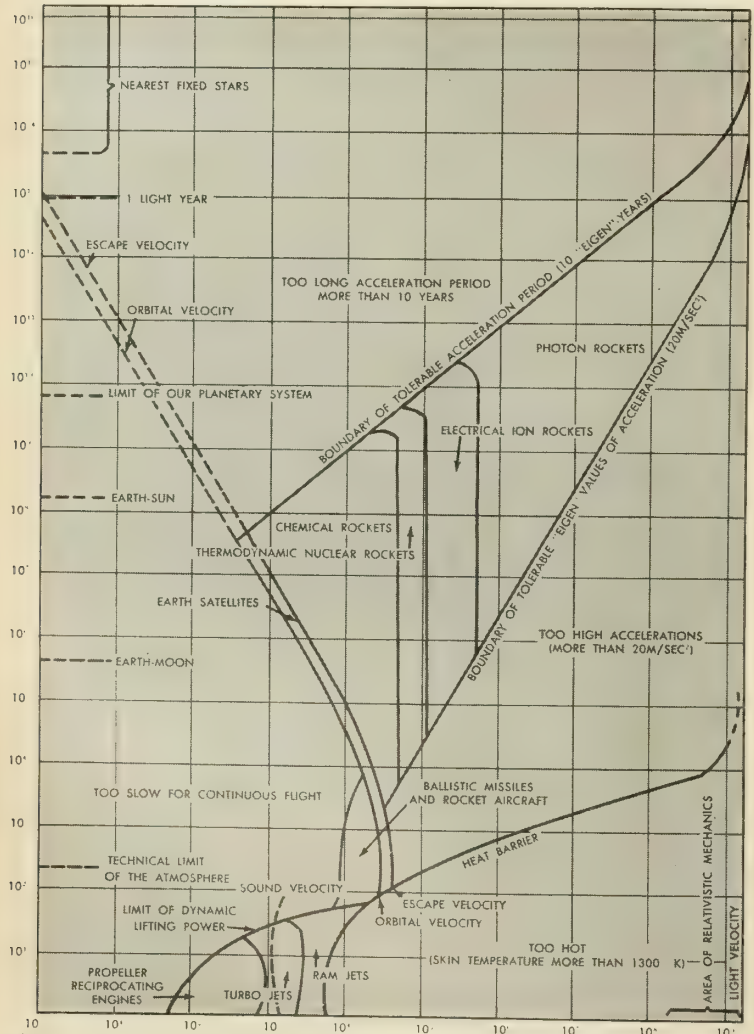
yer has always been invested in the mores of mankind from which he must extrapolate principles of justice.

At this time we may postulate necessary rules of space exploration—namely, in any instance where there is reason to believe that intelligent life exists on a planet, no earth spaceship may land without having satisfactorily ascertained that 1) the landing and contact will injure neither the explorer nor the explored; and 2) it has been invited to land by the explored.

The regulation must be adhered to without exception, or we will project into space and perpetuate the bleak and devastating geocentric crimes of mankind. Further, we must conquer certain problems of semantics before we are worthy of space travel beyond our solar system.

This principle is just as old and simple as the basic idea of justice itself. It is a kind of compact not to harm or be harmed.

Metalaw was earlier defined as the law governing the rights of intelligent beings of different natures and existing in an indefinite number of different frameworks of natural law. An intelligent multidimensional creature would probably be so inferior as to require most considerate and sympathetic understanding and treatment by three-dimensional creatures existing in a three-dimensional universe, such as we conceive of mankind. The intelligent mankind concept runs into deep trouble *vis a vis* an intelligent two-dimensional creature existing in a three-dimensional continuum, and problems of metalaw become truly complicated when one considers a man's relationship with intelligent two- and one-dimensional creatures existing in a two- or one-dimentional universe.



The Eugen Sänger schematic diagram illustrating all possible flight regimes. Verticle scale represents flight altitude in kilometers vs. earth velocity in km/hr (horizontal).

With the assistance of Dr. Eugen Sänger and Dr. Irene Sänger-Bredt, the possible types of flight regimes, including those regimes which might philosophically spell the elimination of a dimension, were illustrated by a diagram (Fig. 2). Within this coordinate system are plotted the domains of aeronautics, the transition domain from aeronautics to astronautics and the domain of astronautics.

Proper aeronautics, characterized by air-breathing propulsion systems, reaches up to about 50 miles. It lies between the two well-known limiting curves—namely, the limit of aerodynamics lifting power and the heat barrier. This domain plot shows an onion-peel shape (attaching one onion peel to the next by increasing flight velocities and altitudes) when progressing from propeller reciprocating engines to turbojets and then to ramjets.

Though aerodynamic lifting power is gradually replaced by the centrifugal force from the trajectory curvature beyond a velocity of 62,000 miles per hour, the intersection of the curves of limit of aerodynamic lifting power and heat barrier is nevertheless physically real and constitutes as the utmost limit of the ramjet also the definite limit of aeronautics.

Contrary to this, ballistic rockets and rocket aircraft are not limited by the limit of aerodynamic lifting power due to their "non-airbreathing" propulsion systems and they can fully exploit the lifting support of the inertial forces due to the trajectory curvature from about 3730 miles per hour on, so that their possible altitudes of flight increased to several thousand miles and their flight velocities approach orbital velocity. The aerodynamic lifting power then is completely replaced by the inertial forces of the circular orbit about the earth.

These ballistic missiles and rocket aircraft form the transition domain from aeronautics to astronautics, which flows into the domain of pure astronautics with the reaching of the orbital velocity. Hence, only a small corridor connects aeronautics with astronautics.

Within the narrow band between orbital velocity and the constant $\sqrt{2}$-times larger escape velocity lie the artificial satellites on the earth. This band curves to decreasing flight velocities with increasing altitude due to the decrease of the gravitational acceleration by the square of the altitude over the earth.

Beyond this band there opens the immense vistas of interplanetary, interstellar and intergalactic space flight, in a structural shape surprisingly similar to that of aeronautics according to present concepts. ★

Manned Rocket Aircraft

By Frederick I. Ordway III

THE HISTORY of the rocket airplane can be compressed within a 30 year span, which, offhand, seems a rather considerable period for this almost novel device. Today, we are interested in the rocket airplane for two major reasons. First, the enormous power made available in a relatively small package allows very high velocities to be built up over short periods of time. Second, the rocket airplane offers an important research potential.

There is no particular difficulty in discussing the history and developments of the pure rocket airplane: it either does or does not have solely a rocket powerplant.

Little attention will be given to pure JATO applications of rocket power. A B-47 or an F-84 are completely operational without considering the fact that they may employ rocket-assisted take-off techniques. On the other hand, the XF-91 was as much built around its rocket engine as it was around its turbojet.

The world's first rocket airplane flight took place in Germany. Germany, too, put the first operational rocket fighter into the skies during World War II. Since then, the United States, France, Great Britain and Russia have made varying efforts in this pioneering field, and it seems that, in one form or another, rocket airplanes are with us permanently. The first manned spaceships may well be extrapolations of today's rocket-powered research aircraft.

For a brief rundown, Germany and Japan are largely identified with wartime efforts; the United States has led the world since then; France is assuredly Western Europe's greatest rocket plane promoter; Great Britain is moving ahead rapidly; and Russia represents somewhat of an unknown.

German Developments

Germany developed the first rocket plane in the 1920s. M. Valier conceived of a project wherein solid rockets would power a small airplane with an auxiliary piston engine for emergency.

On July 11, 1928, at Wasserkuppe, F. Stamer attempted a flight with a rocket-powered glider made available by the Rhon-Rossitten group. Slow-burning Sander's 25- and 30-pound-thrust solid rockets used initially failed to get the plane off the ground. On a third attempt, with two 40-pound-thrust units, take-off occurred, and a 4000-foot-long run of just over a minute was recorded. Later attempts were unsuccessful.

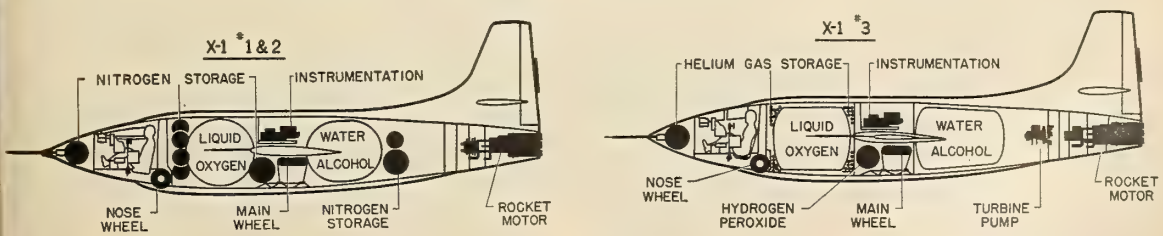
The Opel-Sander-Hatry (pilot-rockets-builder) rocket airplane, with Fritz von Opel as pilot, succeeded in flying on Sept. 30, 1929, at Rebstock (Frankfort) after two preliminary attempts. Power was provided by 16 powder rockets. The flight was nearly a mile long, lasting over a minute. Top speed was reported to be some 70 miles per hour. There was also a tailless *Espenlaub* plane with a 300-pound-thrust engine which could get off the ground very rapidly.

Several events led directly into Germany's wartime rocket airplane developments. Work began at Hellmuth Walter Kommanditgesellschaft in Kiel around 1935 on hydrogen peroxide engines, and thrust ratings went up from 650 pounds to over 2000 pounds in 1938. Turbopump systems gradually replaced pressurized gas feed systems, and bipropellant philosophy gradually replaced the monopropellant.

The first real rocket airplane appeared toward the end of 1938. The Heinkel He-176 reached about 550 miles per hour on a 1300-pound-thrust liquid Walter engine. Walter's engines were beginning to prove themselves and it was not long before other planes, such as the Messerschmidt Me-163 *Komet* mid-wing monoplane and the Bachemwerke *Natter* ram rocket, were using them.

The Me-163 took off and landed much like the modern *Baroudour* in that it jettisoned its take-off assembly and landed on skids. A short plane, the Me-163 was 20 feet long and had a wing span of 32 feet. It weighed up to 11,000 pounds and had a normal 52 pounds per square foot wing loading, which became 14 pounds per square foot when its propellants were exhausted. It featured sharp leading-edge sweepback.

Two major engines were used on different models of the plane: a "cold" engine operating only on T-stoff, while a "hot" engine used bipropellant C-stoff and T-stoff. With the latter combination the plane could reach nearly



Drawings illustrate the internal arrangement of the X-1 series of research rockets. Basic changes are noted in gas storage.



The X-1A, a modification of the "sound-barrier buster," reached a velocity of Mach 2.5.

600 miles per hour, but could fly only about 10 minutes.

At one time during the development program the Junkers firm took over the concept for improvement recommendations and came up with the Ju-248, a somewhat slimmer design. Messerschmidt got it back, however, and the Me-263 resulted, a plane that never was tested under powered flight.

The *Natter (Viper)* was the smallest rocket airplane concept to come out of war-time Germany, and it reached the flight test stage. Four solid diglycol 109-533 boosters made by Schmidding would lift *Natter* at a rapid rate of ascent. Subsequently a Walter C/T-stoff engine would take over.

Vertically launched, the all-wood *Natter* was cheap and could be built rather quickly. From 24 to 33 electrically-fired 7.3-cm *Fohn* air-to-air rockets were carried in the nose and fired simultaneously; once the attack had been made, the pilot would parachute to ground and the motor would jettison and likewise be parachute-recovered. With under 8000-pounds thrust, it had an acceleration of 2¼ g. The top speed was just over 600 miles per hour, and its ceiling was under 10 miles.

Natter weighed about two tons and incorporated an autopilot used until final closure, when the pilot was to take over. Some 20 pilotless tests were successful, but the one piloted attempt failed.

No discussion of World War II German rocket airplanes is complete without mention of the Sänger antipodal bomber. As far back as the early 1930s Euger Sänger was testing oxygen/fuel oil rocket engines in Vienna and he designed a plane looking much like the U.S. X-1. With Irene Bredt, he developed his wartime scheme of a rocket manned bomber that could hit targets on the other side of the globe.

The bomber would have an apogee of some 160 miles (top speed: four miles per second), which meant it would be well outside the effective atmosphere. Its re-descent path would be so calculated that the plane, upon reaching denser atmospheric layers where aerodynamic forces come into play, would ricochet back into space. By following such a "skip" path its range would be enormous.

In the words of Sänger and Bredt: "The launching and climb of the rocket bomber have the purpose of giving it, with a minimum of fuel consumption, the high velocity necessary to carry it through its long glide path; they are in the nature of an impulse which lasts only for a few minutes." They assumed the bomber would be catapult-launched along a rather long track; in effect it would have been a rocket-sled boost which would provide an initial 1000 miles per hour. This great idea remained in the project stage only, though rumors persist that the Russians have, since the war, developed the concept for their own use.

Sänger and Bredt wrote during World War II the following conception of an attack on New York by an antipodal bomber:

As an example of area attack with single propulsion and full turn, we use the attack on New York at a range of 6500 km. For $c = 4000$ m/sec, the bomb load is 6 tons, and the detailed attack runs as follows: the motor starts to work 36 seconds after the take-off at 12 km. distance from the take-off point, and consumes the total fuel supply of 84 tons in the next 336 sec. At the end of the climb process, the aircraft reaches a velocity of 6370 m/sec, an altitude of 91 km., a distance of 736 km. from the point of take-off, and a weight of 16 tons. Using only its store of potential and kinetic energy, the bomber flies on to the point of bomb release, 5550 km. from the take-off point and 950 km. in front of the target. At this point, which is reached 1150 sec. after take-off, the velocity has decreased to 6000 m/sec, and the stationary altitude to 50 km. After the bomb release the weight is 10 tons. Then the aircraft goes into a turn and in 330 sec. goes through a turn-spiral 1000 km. in diameter until it has reached the direction for the return flight to the home base. During turning, the altitude is greatly decreased in order to develop the aerodynamic forces necessary for the turn. At the end of the turn path, the velocity is still 3700 m/sec and the corresponding stationary altitude is 38 km. The supersonic glide path in the direction of the home base goes over 5450 km. in 2600 sec and ends 100 km. before the home base at an altitude of 20 km. and velocity of 300 m/sec. Subsonic glide and landing are completed in customary fashion. The whole flight lasts 4755 sec.

Japanese Rocket Airplanes

The story of Japanese rocket airplanes concerns essentially the *Baka*

Me 163B (General)

Contractor: Messerschmidt	
Years	1943-45
Powerplant mfg.	HWK liquid rocket
Powerplant type	109-509A
Powerplant weight, lbs.	365
Thrust, lbs.	3300 max.
Propellants	C-stoff, T-stoff
Specific impulse, lb.-lb./sec.	180-190
Firing time, min.	4½ (full thrust), 10-12 otherwise, and possibly to 20 min. by using intermittent glide techniques.
Airplane length, ft.	20
Airplane span, ft.	32
Airplane weight, lbs.	9000-11,000
Payload, lbs.	1500
Range, miles	22 (after climb at 495 mph)
Altitude, ft.	40,000
Speed, mph	450-620

The Me-163 Rocket Fighter Program

Model	Velocity (max. mph)	Powered flight time (min.)	Rate of climb (ft./min.)	Engine No.
163A		3¼		R11-203
163BO	555	10	16,000	109-509A
163BI				109-509BI
163C	590	12	12,500	109-509A2

Rocket Engines Used During Me-163 Programs

Year	Me-163 model	Engine model	Thrust range (lbs.)	Engine weight (lbs.)
1941	A	R11-203	330-1650	165
1943	B0	109-509A (R11-211)	660-3300	369
1944	BI	109-509BI	220-4400	440
1945	B	109-509A1	220-3520	370
	C	109-509A2	440-3740	390

Natter Models

Mark	Model	Engine	Powered flight time (min.)	Rate climb (ft./min.)	Velocity (mph)
1	BP-20B	109-509A1	2-4	37,400	620
2	BA-349A	109-559	2-4	.....	...
3	BA-349B	109-5090	2-4	37,300	620

Natter Engine Comparisons

Model	Thrust (lbs.)
109-509A1	220-3520
109-509D	880-4400
109-559	330-3750
(109-509A-2)	(possibly up to 4410)

piloted but powered bomb. They had their *Shusui* version of the Me-163, developed by the Navy, and other piloted bombs referred to *(Kikka, Toka,* etc.), but the *Baka (Marudai)* was their key development.

The *Baka* fired its rocket immediately after release from the mother airplane, and upon burnout glided to target, or it could initially glide and employ rocket power in terminal approach. The bomb generally was launched at altitudes up to 5000 feet and perhaps six or seven miles from the target. It could fly 60 miles if launched from 27,000 feet. The pilots would enter the *Baka* from a hatch in the bomber, much as they do today in entering X-1-type rocket airplanes.

Baka was attached by a mounting lug and a series of slings. Like the *Natter, Baka* was of wooden construction, with fabric-covered plywood surfaces. The guidance system, however, was unlike the *Natter*. First, there was no initial autopilot operation, and second, the human guidance system was considered expendable. Three solid-propellant rockets propelled *Baka,* though the idea of using additional wing-mounted rockets was considered in view of ground launch. The solid charge was a monoperforated double-base powder. If the weapon was launched at maximum altitude of 27,000 feet, it glided for 52 miles at about 230 miles per hour at a glide angle of 5° 35″. Then its rockets took over and during the last three miles speed went up to more than 530 miles per hour. If rockets were used during steeper glide angle, velocities increased to over 600 miles per hour.

Baka was clearly a desperation weapon and one that could be employed only by a nation that could accept the planned expendability of life without even a one per cent chance of survival. While there were many ingenious features to *Baka,* its maneuverability was poor, and except during its brief powered flight, it was susceptible to enemy countermeasures. It seems certain that *Baka* represented one facet of rocket power airplane philosophy that is destined not to reappear.

American Rocket Airplanes

There is a certain resemblance to early American rocket-plane progress in the case of Germany. The former, like the latter, started off by outfitting gliders with solid rockets which had no important effect. For example, back in 1933, 86 solid rockets were supposed to have powered an airplane called *Spirit of Night.*

Similarly, the first practical rocket plane in this country was a military interceptor type, and it was developed under the cloak of secrecy during World War II. It was the Northrup MX-324 flying-wing design, with a span of less than 30 feet. Like the Me-163, it used a liquid engine, in this case the Aerojet XCAL-200, which produced 200 pounds of thrust on red fuming nitric acid and monoethylaniline. The pilot operated the plane while in a prone position, allowing a thin airfoil and permitting him to withstand considerable g-forces. The first flight occurred in July 1944 in California. Some models took off and landed on skids.

Once the feasibility of a rocket airplane was established, the Army Air Force approached Bell Aircraft in 1944 to apply the principle to the problem of designing a research airplane that could explore the transonic and supersonic flight regimes. At the time they wanted 800 miles per hour at 35,000 feet for two to five minutes of flight.

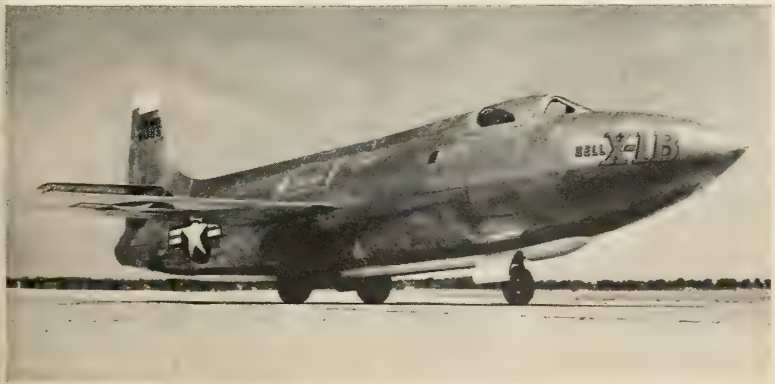
Bell first looked at a turbojet-rocket combination, then decided to use rocket power alone.

AAF went to Reaction Motors for its 6000-pound-thrust liquid-propellant rocket engine being developed for Navy use. This four-chamber engine could provide thrust levels of 1500, 3000, 4500 and 6000 pounds. Weighing 210 pounds, it occupied a space four and one-half feet long, with an elliptical cross section having an 18-inch major axis and a 13½-inch minor axis. Thus Bell Aircraft Corp. and Reaction Motors started off on the X-1 series of rocket airplanes that have since broken altitude and speed records and have accumulated vast quantities of data on manned flight at the aeronautical frontiers.

The RMI 6000 rocket engine compared most favorably with the German Walter 509s in that it developed nearly twice the thrust, yet weighed a third less.

The X-1 program has been widely discussed, so that here we shall content ourselves with salient details only. The X-1 weighed 13,400 pounds and was 31 feet long. The thickness/chord ratio was 8 per cent, and it weighed 4890 pounds empty. In 1946 some 10 glide tests were made from B-29s in Florida, and on Dec. 9, 1946, the first powered flight took place. The program was designed to gather data on drag, heat, stability and pilot physiological strain at high speeds and altitudes. The airframe was stressed for +18g and −10g. The following summarizes highlights of the X-1 program.

Like the X-1, the later (1951) X-1A was generally air-launched from specially modified B-29s (later B-50s). This model had the same RMI 6000-pound-thrust engine, but it could carry



The X-1B was designed to test the effects of aerodynamic heat on aircraft structures.

twice the propellants and featured a turbopump assembly rather than a gas-pressurization feed system. It was somewhat longer than the X-1, fired for over four minutes, and glided in for a landing at 150 mph. It was delivered to Edwards Air Force Base for test in November 1953, and within a month had reached 76,000 feet and Mach 2.5.

A second X-1A, with 4 per cent thickness/chord ratio and aspect ratio of 4 (versus earlier 6) was ready in early 1955 but exploded and was jettisoned from the parent plane. Along with the X-1A were the X-1B, X-1D and the currently used X-1E, last of the series. All operate on alcohol-water liquid-oxygen propellants. Essential data on these planes are presented in chart form.

The Douglas D-558-2 *Skyrocket* used the same 6000-pound-thrust engine as the Bell X-1 aircraft, and has the distinction of being the first plane in the world to reach Mach 2 in level flight. It was also the first plane to exceed 80,000 feet, its record being 83,235 feet (achieved by Bridgeman in 1953). It was outfitted with an air-conditioning system capable of maintaining cockpit temperature at 70°F during high-speed flight. Navy and NACA sponsored the research airplane.

In November 1947 the plane was ready and the first flight took place in February 1948, using only its Westinghouse jet-engine power. The rocket



The X-1E was the last of the X-1 series. It investigates high speed heat problems.

powerplant was still not ready. In February 1949 a combined rocket-jet flight was made. Later, air-launching techniques were employed, and in August 1953 an all rocket-powered flight was made which carried it to its record altitude. In November of the same year the record 1327-mph (Mach 2.01) flight was made.

Another Bell Aircraft development was the X-2, which was larger, heavier and faster than others of the X series. The history of the X-2 dates back to 1947. Delivery of the first unit was made during the summer of 1952. With small, swept, stainless-steel wings and a thick-walled nickel alloy fuselage, it was powered by a Curtiss-Wright XLR-25-1 variable thrust liquid-propellant rocket motor producing more than 15,000 pounds of thrust. The cabin was heat-insulated and all controls were power-boosted. The first of the X-2s exploded over Lake Ontario in May 1953, but the second went on to achieve aeronautical triumphs before it, too, was destroyed.

The X-2 used heat-resistant glass and heat-resistant alloys for all stressed parts. (At Mach 3, temperatures up to 350°C were expected.)

It made its first gliding flight in August 1954. Its first powered flight took place at Edwards AFB, California, in November 1955, and by July 1956 it had reached 1900 mph and an astounding altitude of 126,000 feet. Its record flight on September 27, 1956, brought it to Mach 3.1. On this flight, the "thermal barrier" research aircraft

German Rocket Airplanes

Airplane	Data	Comments
Antipodal bomber	Loaded weight: 220,500 lbs.; payload up to 672 lbs.; propellants: liquid oxygen/gas-oil; length: 91.8 ft.; thrust: 220,500 lb.	Project only; conceived in 1936, suspended in 1942; work performed at the Research Institute for Rocket Propulsion; designed to reach 93 miles altitude and 14,600 miles maximum distance from launch base.
Ar-234	With 45-second endurance, could reach 36,000 ft. in 3 minutes.	Made by Arado, with BMW turbojet and rocket.
DFS-194		High-speed interceptor investigated by A. Lippisch.
DSF-228	The 109-509A1 slated for this design.	A DSF-Siebel concept rocket reconnaissance craft. Prototype built and flown; was to have been operational up to 100,000 ft.
DSF-346	Two liquid rockets for Mach 2.6 speed.	Also DSF-Siebel design concept, scout bomber; initially a research type.
He-176	Walter liquid rocket on Heinkel airframe.	First flew in 1938; not operational.
Julia, P-1077	Thrust variable from 440 to 3750 lbs. over short periods; loaded weight: < 5000 lbs.; empty weight: 2000 lbs.; range: 40 miles; velocity: 500 mph.	Also a Heinkel development, it was a VTO type with four 2600-lb.-thrust, 10-sec. boosters plus a Walter liquid sustainer. Rate of climb about 40,000 ft/min.; skid landing. It was not built.
Ju-248	Approx. 26 ft. long; weight: 11,700 lbs.; range: approx. 100 miles; velocity: 620 mph; maximum thrust: 4430 lbs. Designed to reach 40,000 ft. in 3 minutes.	Used 109-509C1 liquid rocket engine; slimmer than the Me-163; a target defense plane. Only one was constructed.
Me-163B	See separate chart.	See separate chart.
Me-163C	Weight: more than 11,000 lbs.; designed for 590 mph, 52,000 ft. altitude. Endurance of 15 minutes at 500 mph.	A mid-wing monoplane, it evolved into the Me-262.
Me-262	Weight: 18,000 lbs.; thrust of liquid rocket: 2750 lbs.	BMW-718 rocket engine with BMW or Jumo jet engines; also designed to use one or two Walter rockets.
Me-263	Length: 25.9 ft.; span: 31.3 ft.; maximum thrust: 4430 lbs.; weight: less than 12,000 lbs.; velocity 620 mph (max.); rate of climb: 13,800 ft/min.	Used 109-509C1 engine; glide-tested only, however. Was a pure rocket fighter design. Development started by Junkers, turned it over to Messerschmidt. Ju-263 designation also seen.
Natter, BP-20B	Length: 18.75 ft.; span: 10.5 ft.; climb rate: 35,000 ft/min.; 2.2 g acceleration; 12 mile radius of action; cruising speed: 496 mph (max. at 16,000 ft.: 620 mph).	Had four SR-34 solid boosters (109-533 diglycol) by Schmidding, and a liquid Walter rocket (recoverable). Pilot rode forward of wings. Largely wood construction.
P-1104	Rate of climb: 39,000 ft/min.	Messerschmidt design, pure rocket interceptor. Mk-108 armament visualized.
Ta-183		Focke-Wulf jet/rocket, twin-boom airplane.
Volksjaeger, He-162	Design endurance: 45 minutes.	Heinkel rocket fighter project.
Walli, EF-127, -128	Length: 26.4 ft.; span: 20.6 ft.; weight: < 6500 lbs.; range: 60 miles; speed 630 mph. Thrust was variable from 440 to 3750 lbs.	A target defense fighter, not built; rocket engine only, i.e., not jet auxiliary.
Zeppelin Ram Design		To have been used for ramming; solid-propelled, like the Japanese Baka.



This variable-thrust rocket plane has reached the highest velocity and altitude to date.

crashed, due probably to loss of directional stability. Pilot Apt was killed.

The X-1E and the X-2 do not end the American rocket airplane research program. There are apparently at least two others. The first, the rumored Douglas X-12, is somewhat indefinite, but is supposed to be capable of reaching Mach 5, a range of 500 miles, and an altitude of 140 miles. It may be a Navy-DNR project. Details on the second, the North American X-15, are shaping up rather rapidly.

The X-15 is an Air Force-, Navy- and NACA-sponsored project and will be designed to probe two main unknowns: the effects on airplane and man of Mach 5-6 flight, and the effects on airplane and man of flight 100 miles or more above the earth's surface, including specifically heating, control, stability and re-entry.

What we are to see, in effect, is a manned spaceship, powered by a Reaction Motors 60,000-pound-thrust rocket engine and capable of operating in the void. An interesting fact about the airplane is that it is considered quite safe, despite the frontier regions in which it will fly. It has been thoroughly "human engineered," and aeromedical experts have labored on the project side by side with the aeronautical engineers. It will probably make its first test glide from the Edwards AFB flight test center in 1958.

The X-15 will have to be versatile to explore successfully a variety of speed regimes at a variety of altitudes. Top speeds will presumably be attempted at extreme altitudes—100 miles or so. Re-entry will be critical, and it is obvious that aerodynamic glide descent techniques will be employed. Results from X-15 flight testing are sure to be directly applicable to one of the most important facets of astronautics—descent onto planets with atmospheres.

Oddly enough, the United States has seemed to pay little attention to the rocket-powered military aircraft. Nevertheless, in the early 1950s, the development of an experimental rocket-turbojet interceptor airplane was sponsored by the Air Force. It was designated the XF-91 and was handled by Republic Aviation Corp.

It is noted mainly that it was the first U.S. rocket-powered combat-type fighter to exceed the speed of sound. This it did late in 1952 on a flight out of Edwards AFB. Test flights started in 1949, the first on May 9.

XF-91 had two powerplants, a GE J-47 developing 5200 pounds of thrust, and a Reaction Motors 6000-pound-thrust liquid rocket of the same type used on the Bell X-1 and Douglas D-558-2 research airplanes.

An interesting feature of the plane was the inverse taper on the swept-back wings, which reduced wingtip stalls due to lift loss. The wing also showed variable incidence, which allowed a high angle of attack for take-off and landing and low angle of attack for level operation. Pressurization and refrigeration were provided.

There are known to be other rocket airplane projects in the United States but details are not available. A rocket engine recently exploded during test at Reaction Motors, killing or injuring both RMI and Chance-Vought engineers. This set off new rumors about a suspected rocket airplane that may be under development by the two firms.

The Air Force has already predicted manned flight at Mach 10 within 10 years, which is double the speed assumed for the X-15. Rocket engines will gradually increase in power, and we may hear more of the turbo-rocket motor. Marquardt has one under development where the efflux of the rocket engine is passed through a turbine driving a compressor. Ram air is compressed and, by suitable ducting, is made to join the turbine exhaust, providing thrust. Aerojet-General has reported making studies of a 2000-mph commercial airliner which, it feels, could be available within 20 years.

This rocket-powered commercial airliner proposition was well publicized about a year ago in a series of articles by Dornberger. He visualized a two-stage rocket glider which would travel from 7000 to 11,000 mph at an altitude of between 25 and 35 miles. It would slow to 2700 mph for re-entry, and essentially would be automatically controlled.

Characteristics of Baka

Length (ft., in.)	19' 10"
Span (ft., in.)	16' 5"
Wing area (sq. ft.)	64.7
Wing loading (lbs./ft.²)	70
Weight (lbs.) (with 120 lb. pilot)	4535
Weight, warhead (lbs.) (with 1135 lb. explosive)	2645
Weight, airframe	1000
Weight, propulsion unit (lbs.)	768
Length, propulsion unit (ft., in.)	6' 6"
Thrust (lbs.) (max.) (average: 1500)	4500
Average firing time at 60° temperature (sec.)	~ 10
Velocities, considering maximum total horizontal range case (mph)	
1 rocket fired	350
2 rockets fired	455
3 rockets fired	535
(Note: Level flight speeds)	

French Rocket Airplanes

In the west France can be considered the European leader in the application of rocket power to airplanes, and is apparently the world leader when it comes to rocket combat-aircraft progress.

Her outstanding development at the moment is the *Trident* II SO.9050 airplane, which has been so successful that not only the French manufacturer, but German, Dutch and Belgium firms, have recommended that their governments adopt it as an interceptor.

The II model was preceded by the

Comparisons of U.S. Rocket Aircraft

Item	X-1	XF-91	D-558-2	X-1A	X-2	X-15	The Future
Velocity (Mach No.)	1.4	> 1	2.1	2.5	3.1	5-6 (design)	10
Altitude (ft.)	73,000	...	83,000	90,000	126,000	500,000 (design)	1,000,000
Thrust (lbs.)	6000	6000	6000	6000	15,000	60,000	100,000 or more
Length (ft.)	31	43' 3"	45	35' 7"	...	...	...
Span (ft.)	28	31' 3"	25	28	...	...	...



The Fairey DELTA I is the British entry in the rocket research airplane field. Craft utilizes a liquid rocket for assisted takeoff and a conventional turbojet for cruise.

experimental SO.9000 *Trident* I, which in May 1955 reached supersonic flight in climb. Its main powerplant was a three-chamber SEPR481 (earlier 25) liquid-rocket engine with MD-30 *Vipers* on the wingtips as auxiliary jet engines. Both I and II were conceived by French designer Servanty, and the first "jet only" *Trident* I flight was made on March 2, 1954 with Jacques Guignard at the controls. Charles Goujon took it on its first rocket flight early in September of the same year. Though the rated thrust was about 9900, it actually built up 10,500 at sea level and 11,500 pounds at 40,000 feet.

The plane features short, thin, straight wings with no ailerons. It is light and fast, being designed for Mach 1.6 flight. Highly maneuverable, *Trident* I's rockets can be fired or turned off at will, both simultaneously or in sequence. The SEPR481 is believed to have undergone over 1000 ground tests and 125 flight tests during the development period. Specific impulse is 208-16 lb./sec. at high altitude.

SO.9050 *Trident* II is very much like *Trident* I. Apart from improved lift and aerodynamic considerations and a slightly shorter span, there is little to distinguish the two. *Trident* II uses two wingtip *Vipers*, but is shifting to Turbomeca *Gabizos* with afterburners at the present time. It has a two-chamber furfuryl alcohol-nitric acid SEPR631 rocket engine developing 6600 pounds of thrust. It makes use of honeycomb material and metal-to-metal bonding, is light, fast (has reached Mach 1.9 already and is designed for Mach 2 flight), and is operational at 50,000 feet. (It has attained 59,000 feet.) The plane is not area ruled.

This single-seat interceptor was first flown with jets only in July 1955 at Istres, near Marseilles, and in December Goujon took it on its maiden rocket flight. Since then more than 100 test flights have been made successfully. The plane is attractive to Europeans since it is simple, easily and cheaply produced, can be serviced rapidly, and can land on and take off from poorly prepared, small airstrips. (It needs about 1500 feet, and lands at 100 mph.)

It is a high-altitude interceptor that can patrol for a considerable time before making its supersonic close-in. It is reported capable of reaching 50,000 feet in two-and-one-half minutes. At the present time its ceiling is governed by pilot survival considerations only. The cabin is pressurized and has a canopy that can be jettisoned together with an ejector seat. Ten are on preproduction order by the Air Force. Production facilities are at Courbevoie.

Sud-Est's (now Sud) SE.212 *Durandal* may be dropped in favor of mass producing the *Trident* II. This mixed-engine interceptor first flew from Istres on April 20, 1956, with Pierre Maulandi at the controls. Like the *Trident*, delta-wing *Durandal* is a light, anti-bomber airplane that can make a sustained supersonic climb without even utilizing its rocket. More than 100 flights have been made.

Power is given by a SNECMA *Atar* 101-G-21 jet building up 9900 pounds of thrust and an SEPR rocket engine developing 3300 pounds. *Durandal* weighs about 12,000 pounds and has an announced speed in excess of Mach 1.5. Its armament consists of air-to-air homing missiles. A new, faster *Durandal* IV with an *Atar* 9 13,230-pound-thrust jet plus rocket is now being developed.

The *Espadon* SO.6025 (and 6026) jet-rocket airplane was used as a test bed for *Trident*'s rocket engine. At least 60 flights with the SEPR251 were successfully made, the first on June 10, 1952. Thrust was 3300 pounds, firing time 3.25 minutes. *Espadon* led directly into the current crop of French rocket airplanes, and was the first rocket plane developed in Europe since the war (Russia excluded).

Another mixed light interceptor is the *Griffon* 1500 (ex *Guepard*) of Nord-SFECMAS. This has an *Atar* 101-G with afterburner and two 2400-pound-thrust rocket chambers. It weighs 9000 pounds, has a Mach 1.3 velocity and first flew in September 1955. Nord's *Harpon* is a similar type. Dassault's MD-550 is a delta-wing airplane with *Viper* jets and an SEPR

X-1 History

1946	First powered flight (speed: Mach 0.795 at half throttle)
1947	Speed of sound exceeded in level flight (by Capt. C. F. Yaeger)
1948	Maximum speed of 967 mph attained
1949	Take-off from ground (2300-ft. run at full power; plane reached 23,000 ft. in 100 sec.)
1949	Maximum altitude attained (73,100 ft.)
1950	Retirement of X-1 to National Air Museum* in August

*Two other X-1s built, one of which had a turbopump assembly and exploded in November 1951.

U.S. Rocket Airplane Velocity Records

Plane	Velocity record
X-1	First to reach Mach 1
D-558-2	First to reach Mach 2
X-1A	First to reach Mach 2.5
X-2	First to reach Mach 3
X-15	Designed to reach Mach 5-6

The USAF-NACA-Bell X-1 Series

Plane	Remarks
X-1	See separate chart.
X-1A	Speed record set in Dec. 1953; altitude in June 1954. Air-launched at > 25,000 feet; duraluminum construction; ejection seat; tempered glass windshield.
X-1B	Like X-1A, weighs about 18,000 lbs; carries 1000 lbs. of special instrumentation; used from 1955 to determine effect of heat on structures.
X-1C	Cancelled.
X-1D	Destroyed in August 1951.
X-1E	Undergoing test. High speeds expected due to lighter airframe, less volume taken up by turbopump; heat studies being carried out.

SEPR Developments

Item/Number	25 (Guepe)	66 (also 661)	73	732	481	505	505-2	631
Type	auxiliary	sustainer & auxiliary	booster	booster	sustainer	booster	booster	sustainer
Propellants	f/na[1]	f/na	solid	solid	f/na	solid	solid	f/na
Thrust (lbs.)[2]	3300	3300	55,000	44,000	9900[3]	22,000	29,700	6600[4]
Firing time (sec.)	[5]	[5]	4	4.5	[5]	4.5	4.5	[5]
Total weight (lbs.)			1625			884	1030	
Engine weight (lbs.)	190	308		510				
Propellant weight (lbs.)			940				628	
Length (ft.)	4.92	9.2	8.8		turbopumps: 2.62 chambers: 5.91	7.9	8.8	
Width (ft.)	1.67	1.97	2.1		turbopumps: 1.90 chambers: 2.02		1.6	
Height (ft.)	1.43	0.98	2.1		turbopumps: 2.62 chambers: 2.02		1.6	
Typical application	Espadon	Mysteré IV, Mirage III	SAMs	SAMs	Trident I	SAMs	SAMs	Trident II

[1] furaline/nitric acid
[2] usually ±5%
[3] 3-chamber, at 3300, 6600, 9900 levels
[4] 2-chamber at 3300, 6600 levels
[5] variable

liquid-rocket installation. Capable of Mach +1 flight, it first flew in Bretigny in May 1955. Its armament consists of air-to-air missiles and 30-mm cannon. This plane is better known as the *Mirage* I.

Mirage II used two Turbomeca *Gabizos*, plus its two-chamber, 2400-pound-thrust SEPR rocket. *Mirage* III is today's version, having a SNECMA *Atar* 101-G with afterburner and the liquid SEPR rocket rated at 3300 pounds at sea level. Turbine cooling is achieved by using a methyl alcohol-water combination to cool generator gases.

Flight testing of this interceptor and tactical support craft began in November 1956. Area ruled, *Mirage* III is 35 feet long, has a 26-foot span, and weighs 11,000 pounds. Its armament can consist of 30-mm cannon, air-to-air rockets, bombs, napalm, and so forth. It has a long-range search and missile-control radar, can be zero-launched and land on skids, or it can operate conventionally from small, poorly prepared strips. It flies between Mach 1.5 and 1.7. *Mirage* IV will be outfitted with an *Atar* 9, and should operate in the Mach 2 region. The SEPR66 rocket engine powering the *Mirage* has seen very extensive ground and flight testing.

The French Air Force may order "hundreds" of the III model.

British Rocket Airplanes

Despite the seemingly obvious requirements for extremely rapid manned interceptors, Britain has not given as much attention to rocket airplanes as France. Back in 1950 the Ministry of Supply backed a Fairey VTO project which employed not only a two-chamber *Beta* 1800-pound-thrust liquid sustainer but two solid boosters developing a total of 1200 pounds thrust. The announced object of this program was to determine the practicality of vertically launching interceptors at low accelerations.

With a delta-wing configuration, it featured autopilot control, correcting the vehicle's path by deflecting the thrust line of the upper chamber. The VTO was presumed to be a test vehicle for an advanced FD-1 research airplane.

Other than this VTO project, the British are rumored to be considering a rocket bomber, though no details have been made public. The Avro.720 rocket-jet interceptor project was cancelled some time ago during an economy move. The major current development program involves the Saunders-Roe S-R.53 (a competitive design to Avro.720), about which a number of details are known.

Before going on to the S-R.53, however, it is well to stop long enough to mention briefly some of Britain's rocket engine developments. In discussing them, the question again arises: "When, exactly, do you have a *rocket airplane* and when do you merely have a *rocket-boosted airplane?*"

Generally, it is felt that if the engine is permanently installed and is used for purposes other than just help-

French Rocket Airplanes

Air-plane	Desig-nation	Manu-facturer	Liquid rocket engine thrust (lbs.)	Velocity (Mach No.)	Remarks
Durandal	SE.212	Sud (ex-Sud-Est)	3300 x 2(?)	> 1	Delta-wing; bomber destroyer; supersonic in climb
Espadon	SO.6025 (6026)	Sud (ex-Sud-Oeust)	3300	> 1	Test airplane leading to Trident; post-war Europe's first rocket airplane; SEPR 25 then 251
Griffon	1500	Nord/SFECMAS	4800	1.3	Has Atar with afterburner; weighs 9000 lbs.
Harpon		Nord	4800	> 1	Similar to Griffon
Mirage I	MD-550	Dassault	3300	∧ 1	Delta-wing; first flew May 1955; armed with air-to-air missiles; has Viper jet.
Mirage II		Dassault	2400	> 1	Like I, with Gabizo jet.
Mirage III		Dassault	3300	1.7	Like I, with Atar 101-G jet with afterburner; area ruled; strong competitor to Trident II.
Mirage IV		Dassault		2	Like I, with Atar 9; not yet ready.
Trident I	SO.9000	Sud (ex-Sud-Oeust)	9900	> 1	SEPR 481 rocket & Viper wing tip jets; experimental
Trident II	SO.9050	Sud (ex-Sud-Oeust)	6600	1.9	In pre-production; like I, with shorter span; Gabizo jets; SEPR 631 rocket engine; may become standard NATO interceptor; reached 59,000 ft.

British Auxiliary Power Rocket Engines

	Screamer	Snarler
Designation	A.S. Sc. 1-2	A.S. Sn. 1
Developer	Armstrong Siddeley	Armstrong Siddeley
Weight (lbs.)	470	215
Chambers (No.)	1 (earlier, 2)	1
Thrust (lbs.)	800-9500	700-2000
Propellants	liquid oxygen/aviation gasoline/water	liquid oxygen/methyl alcohol/water
Specific impulse (lbs.-lbs./sec.)	208-217	200-200
Chamber pressure, psig	600	280
Remarks	First test, 3-54; first flight test, 12-55. More than 1300 firings have occurred. Program suspended in 1956.	Tested in 1950 on P-1072 interceptor. Can fire 3 minutes at full thrust; prototype flown, 11-47; over 650 firings. Program suspended in 1952.

British Rocket Airplanes

Name	Manufacturer	Powerplant(s)	Remarks
Avro-720	Avro	Liquid rocket plus turbojet	Projected rocket-jet interceptor; cancelled.
Fairey VTO	Fairey	Liquid rocket plus solid boosters	VTO launch test vehicle; possibly for FD-1 research airplane.
S-R.53	Saunders-Roe	Viper jet plus Spectre rocket (liquid)	Now being flight tested; called a recoverable booster for air-to-air missiles.
S-R.177	Saunders-Roe	Liquid rocket	Project only.

ing take-off it should be thought of as an integral part of the airplane design, and not only an added feature.* The RAE *Alpha* rocket engine, for example, was the main engine for a Vickers transonic airplane model, while *Beta* I and II, later, were also used on the aerodynamic research vehicle. *Gamma, Scarab, Scorpion, Sprite* and *Super Sprite* engines are ATO units. The *Super Sprite,* incidentally, is the first British aircraft rocket engine to go into production.

Both the AS.1-2 *Screamer* and the AS.1 *Snarler* are primarily auxiliary powerplants providing surge speed for fighters, and can be stopped and started at any altitude. *Screamer* has been successfully used on the *Meteor* 8, and was considered the successor to the *Snarler* (which was flight tested in November 1950 in the Hawker P-1072). That *Screamer* was cancelled last year despite the fact that it reached the flight clearance stage indicates that the sponsoring Ministry of Supply decided to use peroxide rather than liquid oxygen for its rocket interceptors.

The delta-wing, mixed-power S-R.53 interceptor has been described as a "recoverable booster" for air-to-air missiles, as well as "the most important link in progress between the current orthodox fighter and the unmanned ground-to-air missile of the future." A Saunders-Roe development, its 1750-pound-thrust *Viper* jet engine is a product of Armstrong-Siddeley, and its *Spectre* rocket booster is from de Havilland.

The *Spectre* is presumably an outgrowth of the *Sprite* and *Super Sprite* programs, and has performed well in the S-R.53 application. It is interesting to note that the ratio of jet to rocket propellant can be varied according to the tactical situation.

The *Spectre* rocket engine is the main powerplant of the S-R.53, and not an auxiliary. It is apparently the first British airplane that can really be considered rocket powered.

Little additional information is available on the plane. Its rate of climb is rumored to be 40,000 feet per minute, and it has a large quantity of avionics for automatic control. The S-R.53 first flew at the Aeroplane and Armament Experimental Establishment, Boscombe Down, in May 1957, and can take off from, and land on, small runways.

Reports have it that the S-R.53 will evolve into the S-R.P-177, an advanced rocket interceptor, though there is apparently no official Royal Air Force support for the project. It, too, presumably will employ a *Spectre,* but a *Gyron Jr* jet engine is expected to be used (a scaled-down 15,000-pound-thrust *Gyron*).

It is also probable that the English P.1 will eventually be outfitted with a Napier *Scorpion* rocket engine, making it, too, a mixed fighter. *Scorpion,* as it now stands, has two chambers producing 2000 pounds of thrust each on kerosene or wide cut gasoline. At the present time it provides JATO power for the *Canberra* bomber.

One could consider rocket-powered helicopters, such as Saro's Skecter *to be rocket airplanes. This model has Napier HTP rockets in the blade tips, much like Reaction Motors' ROR (rocket on rotor) projects in the U.S.*

Russian Rocket Planes

Airplane	Velocity	Remarks
Yak-21	700 mph	21-ft. span, 12,000-lb. weight. Auxiliary rocket powerplant (liquid).
La-17	Mach 1	36-ft. span, 16,000-lb. weight. Auxiliary rocket powerplant (liquid).
I-1	1700 mph	Rocket interceptor-type research aircraft. Altitude: 100,000 ft.
I-2	< 800 mph	Liquid rocket VTOL interceptor, with less than 8 min. flight time. Armed with air-to-air missiles, 37-mm cannon.

Russian Rocket Airplanes

We know less about Russian rocket airplanes than we do about Russian missiles. Yet we are fairly certain that Russia has made considerable progress in applying rocketry to aircraft, and it seems likely that German wartime efforts provided the basis for this trend.

There are many indirect indications of Russian interest in rocket airplanes. As Dr. Albert Parry has indicated, the Russians are trying to find out more about "weightless airplane" research, and "non-weight aircraft." It was pointed out that reference was made to work on gravitation in the United States and the Canadian Avro "flying disc." There is also evidence of Russian research on the problems of manned re-entry into the atmosphere in rockets.

For years there have been persistent rumors that the Russians were adapting the Sänger antipodal bomber design to their uses. A T-4A designation has been mentioned, with a range of from 4000 to 10,000 miles. Its apogee has been guessed to be in the neighborhood of 120 miles. It would hold a single pilot, according to some reports, though others hold it would be pilotless.

The Russians have admitted they are thinking about manned intercontinental rockets. On Sept. 20, 1830 hours Huntsville time, the author picked up an interesting broadcast from Radio Moscow. Missile expert Sternfeld, speaking on the program SCIENCE AND ENGINEERING IN THE USSR, devoted 10 minutes to a three-stage Moscow-New York manned rocket with an apogee of 750 miles. Poor reception did not permit further details to be recorded, though cut-off altitudes were apparently mentioned.★



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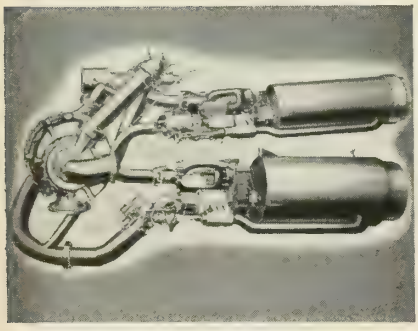
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Human Factors in Space Flight

By Arthur Kahn
Westinghouse Electric Corp.

SINCE THE END of World War II and the accelerated development of rockets and propellants, there has been a renascent interest in the engineering problems of space flight. This has been heightened by the ascent of *Sputnik*.

In the main, most of the effort has been concentrated on the ability to function in a weightless environment and on the effects of high levels of acceleration. Much of this effort has been to determine the limit of the human's endurance rather than his capacity to perform tasks in this environment.

Originally, scientific interest in space flight had been well formed prior to World War II. Oberth's book WEGE ZUR RAUMSCHIFFAHRT (THE WAY TO SPACE TRAVEL) took up many of the technical problems of space travel. Oberth incorporated many of his ideas into a spaceship that was used in a German movie of 1929-vintage entitled FRAU IN MOND (WOMAN IN THE MOON).

Until recently, Oberth's work was the most comprehensive source of space flight data. Much of this book and other material considered the engineering problems involved in constructing a spaceship and the propellants required for developing sufficient thrust to drive the vehicle beyond the earth's gravitational field. There is little mention of controlling the vehicle in flight, in landing on the moon and on the return trip to earth.

Despite this interest in manned space flight there has been little interest among engineers in providing solutions to the human factors problems. Oberth's most recent book, MAN INTO SPACE, devotes little space to the human factors problems other than to record the fact that these problems are being studied at the Department of Space Medicine, School of Aviation Medicine, at Randolph Field.

He indicates the crews for these vehicles must be selected in accordance with rigorous criteria which are not mentioned. With the present intensified interest in space flight, it is necessary to examine some of the problems in which the operator's requirements will determine engineering needs.

The problems involving the operator or operators of a manned vehicle traveling beyond the earth's atmosphere can be divided into four major categories: ecological, perceptual, personality and human engineering.

Physical Orientation

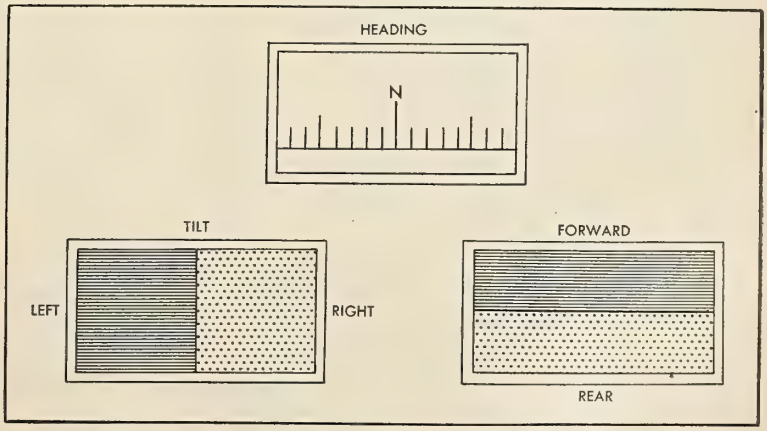
The ecological items are essentially aeromedical problems. Many of these problems now confront the equipment designer in high-altitude flight. The extent to which present operating conditions are akin to space have been indicated by Strughold in using the term "space equivalent" to denote those altitudes at which the human operator could be exposed to conditions within the earth's atmosphere that are similar to those in space. It is necessary to provide a full pressure regime beyond 50,000 feet. Blood "boils" at the vapor pressure that exists at 66,000 feet or 12 miles.

At nine-and-a-quarter miles, the amount of oxygen in the atmosphere is practically zero. At 15½ miles, it is impractical to pump air into the crew's quarters because the air is too thin. It also contains ozone, a poison. The environment must be controlled within reasonable limits by maintaining given pressure levels, humidity and temperatures as well as gaseous content.

A major problem is the removal of gaseous wastes of the respiratory process. In the earth's atmosphere, the CO_2 given off by humans is absorbed by plants which in turn give off the oxygen that man must have to survive.

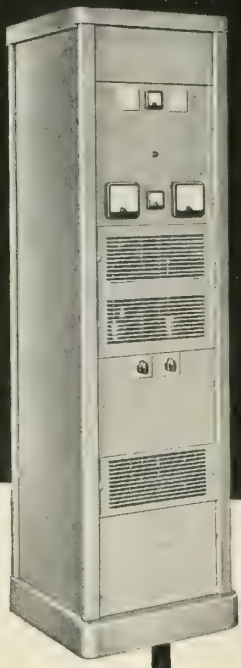
Recent reports from the School of Aviation Medicine at Randolph Field suggest that such a closed system is feasible and can be incorporated into a space vehicle. If this closed system cannot be developed, oxygen must be either carried in the vehicle or somehow manufactured on board. Similarly, provision must be made for removing the CO_2. Protection also must be provided against cosmic radiation.

The problem of temperature and humidity control are related. Although man can withstand temperatures of over 100° for periods of time, he has an upper limit of 110°F. It will be necessary to maintain the temperature at a much lower level, in all probability about 80°F, if he is expected to perform tasks that require accurate computation and difficult decisions. Re-



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search indicates that the optimum temperature will depend on the amount of clothing the operator wears, as well as upon the vapor pressure of the water vapor. It is obvious that it will be difficult to satisfy these requirements because at the beginning of space at about 500 miles from the earth, the temperature is about 900°K.

Psychological Orientation

The personality problems develop from factors in the individual's background. Such obvious problems as claustrophobia, inability to cope with fear of the unknown and social isolation must be considered.

At the present time the Air Force is sponsoring a study on these types of problems at Lockheed-Marietta. Beyer and Sells have discussed some of these problems in their article, "Selection and Training of Personnel for Space Flight." Clark and Graybiel have suggested that in some instances the feeling of detachment from earth may become a problem, particularly where the crew has little to do.

Many similar problems are being encountered in the selection of submarine crews and in the selection of men to man radar and weather stations in the DEW line. These problems emphasize the need for what has come to be known as small group research such as that conducted on combat assignments by the Air Force Personnel and Training Research Center.

Perceptual problems involve the capacity to "visualize" space as a kinematic environment with objects moving about the vehicle. The operator "builds up the space picture" from various sources of information that will be available to him. This is related to the problems of human engineering.

Human engineering factors should be considered in the construction of the various devices and displays that the crew will use to control the vehicle and its internal environment as well as the various equipment the crew may be required to wear.

The displays and controls for a spaceship can be divided into the following groups: (1) ecological systems (mechanisms for controlling the internal environment of the crew compartment), (2) navigation displays and control systems, (3) communication systems displays and controls, (4) displays for showing altitude of the vehicle and propellant conditions and controls for changing the altitude of the vehicle, and (5) the amount of propellant used.

The displays of the ecological system can be specified rather simply: pressure gauges and temperature and humidity gauges. The displays will also show the condition of the equipment maintaining the environment.

If the conventional pressure, temperature, humidity and rpm indicators are used, it would be quite an undertaking for the pilot and co-pilot to monitor all these displays in addition to performing some of the other tasks of navigation, communciation and vehicle control. Obviously, there is need for a display system that will present much of this information in such form that the operator will not be required to integrate various sources of information. The many problems of this one aspect of space flight must be attacked immediately if solutions are to be available when the instruments for these spacecraft are designed.

In developing the navigation displays, the methods used for navigation must be considered. Conley[1] suggests what he calls "V.S.A.—very simple astrogation." In this system, he requires the crew of a spaceship to make calculations of the flight time on a trip to the moon and position the moon at the end of the time of flight, making allowances for the sun's gravity drift.

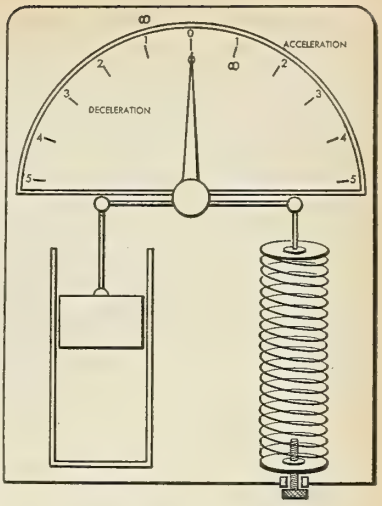
He then requires the pilot to aim the craft at this point. This procedure requires exact knowledge of the position of the craft and a representation of this position on an appropriate display. The design of such a display will require the scaling of the solar system's dimensions into meaningful displays within the aircraft's confines.

Since the available displays for navigation are somewhat unsatisfactory for high-speed high-altitude flight, much work will have to be done in order to develop displays that will be easily interpretable without the integration of information from other instruments. The ability and the ease with which the pilot will be able to "visualize" the space picture about him will depend on how much effort is put into the development of the display.

The problem of communication between the home base and the spaceship is one that must be considered. Clark in his book INTERPLANETARY FLIGHT indicates that it is possible to transmit speech to a spaceship 10 million kilometers away from earth with present-day equipment using a frequency of 3000 megacycles per second and an aerial of one square meter on the spaceship and 100 square meters at the earth's station.

The only problem would be the time lag due to the finite speed of the radio waves, since it takes 1.3 seconds for a signal to reach the moon from the earth. This problem might be circumvented by storing the complete message

[1] J. Space Flight, *Vol. 2, No. 2, 1950.*



Acceleration-deceleration meter.

before reading it out through a speaker system.

Other than the lag problem, the communication problems are no different than those that plague present voice communication systems. Increasing signal-to-noise ratio, cutting down interference and increasing the intelligibility of spoken messages are a few of the present-day problems that will be encountered in spacecraft communications unless solutions are obtained.

The foregoing paragraphs have not covered the problem of control of the space vehicle. Conley[2] has suggested an instrument that might be comparable to the combination of a gyro horizon and a heading indicator in conventional aircraft. Fig. 1 shows this instrument. It is aligned with the vertical axis of the vehicle. It is assumed that the pilot is seated on the same axis.

The instrument gives the angle of the ship to the vertical and to the horizontal as well as the direction of the spacecraft. He has also suggested a design for an acceleration-deceleration meter.[3] This instrument is shown in Fig. 2. He suggests that three of these instruments be mounted so that the sliding tube of the weight of one tube is aligned with each axis of the space vehicle.

The scale is so designed that on the earth's surface, gravity is unity or zero on the scale. If the spaceship were on the surface of the moon, the operator would require three meters to know what accelerations were acting on the ship and himself, plus additional meters for angular accelerations. This information is vital to his assuming a

[2] J. Space Flight, *Vol. 3, No. 3, 1951.*

[3] *Ibid.*

position that will minimize the effect of acceleration. He must have it in some form. With this projected system, he would be required to integrate this information—altitude, position and accelerations on the vehicle.

Conley's work indicates the difficulties that will face the pilot if the displays are attacked in piecemeal fashion. To get information about the performance of the vehicle, the pilot must read all three as well as the tilt meters. In order to control the vehicle, he must integrate all this information into some meaningful whole before he attempts some control action.

Since it is anticipated that the control of a space vehicle will be achieved by the use of rockets arranged about the vehicle, there will be non-continuous control of the vehicle. Current research indicates that with this kind of control, precise movement by a human operator is quite difficult. Research may be required to determine a method of integrating stepwise control so that it appears continuous or a method of obtaining continuous control of rockets through some kind of power control valve. This kind of control might necessitate a new approach to propellants.

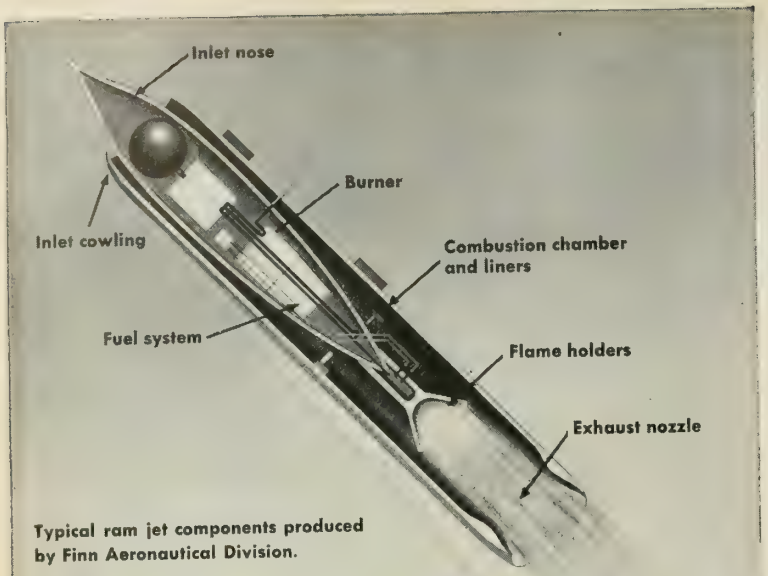
While the ecological problems and physiological effects, including acceleration involved in space flight, are being studied, these problems related to the control and navigation of the space vehicle by a human operator have been neglected. Since requirements for the proper specifications for instrument design are so great, it would be desirable to have a continuous research project to obtain the necessary information.

This research should consider the problem of scaling the physical measurements and variables to the different methods by which the human operator can obtain information. Provision must be made for appropriate gain changing.

Consideration must be given to building computers that can be incorporated into the system with such read-out devices that the crew can achieve an optimum combination of information at any given time. Research should evolve the optimum combination. Provision must be made for automatic log keeping and read-out from this log.

This undertaking should provide the space crew with a set of displays that will minimize the problem of extracting all the information it needs. This information display should minimize control difficulties and the decisions the crew will have to make.

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New Air for Engineers

by Joseph G. Logan, Jr.

Cornell Aeronautical Laboratory, Inc.

IN THE PAST few years, the interest of aeronautical engineers has turned toward higher flight speeds and flight Mach numbers—up to 30,000 feet per second, about 30 times the speed of sound. In the regime between Mach numbers of six and 30, the "hypersonic" regime, the ideal gas concept of air must be abandoned. While this fact will be of principal import to the aeronautical engineer, its effects may extend even to the electronics engineer.

Air at room temperature is, of course, composed primarily of a mixture of oxygen and nitrogen molecules, about 21 per cent oxygen and 78 per cent nitrogen by volume. The remainder consists of small amounts of argon, water vapor, carbon dioxide, hydrogen, neon, krypton, and xenon. For the maximum temperatures encountered in the supersonic flight regime, engineers could regard the molecules of oxygen and nitrogen as rigid dumbbells. In this concept the molecular motions induced by collision were conflicted to translation and rotation. In the hypersonic regime the molecules of air have a much more complicated behavior (Fig. 1).

For example, the temperature behind a normal shock wave at a Mach number of six is about 1500°K (2240°F). As the temperature of the air gradually increases above this point, the molecules cease to behave as rigid dumbbells and begin to vibrate as a result of collisions. At Mach 10 flow the temperature behind a normal shock wave reaches 3000°K (4940°F) and the oxygen molecules begin to break up or dissociate. At these temperatures the molecules and atoms also begin to ionize and collisions between molecules result in the formation of nitric oxide. Similarly, at a flow Mach 17 temperatures reach about 6000°K (10,340°F) and nitrogen begins to dissociate.

The extent to which the composition of air varies with temperature is clarified in Fig. 2. It becomes apparent that, as a result of the breakdown of oxygen and nitrogen molecules at temperatures of about 6000°K, the air can contain as many as 10 different components. The introduction of these new components alters the thermodynamic properties of the air, and forces the aeronautical engineer to discard many of the rules he has lived by for so long.

Flow Phenomena Modified

Recently, calculations of the "new" thermodynamic state of the air at high temperatures, including the specific heat and the speed of sound, have been carried out at CAL. A large increase in specific heat occurs as a result of the new ways in which energy can be distributed in air at high temperatures (Fig. 3). The chart reveals that the specific heat at constant pressure can exceed the ideal gas value by factors of 12 at temperatures of 7000°K. In other words, it takes about 13 times as much energy to raise the temperature of a given mass of air one degree at 7000°K as at room temperatures. Engineers designing hypersonic shock facilities for operation in the 5500°K to 8000°K temperature range find this a real problem.

Another phenomenon observed is the decrease in the molecular weight of air as a result of the increase in the number of particles at high temperatures. The equation of state must therefore be modified to include the molecular weight as a parameter. Normal shock calculations must also be modified to reflect the altered relations between pressure, temperature and density. Accurate knowledge of the state of the air behind shock waves thus becomes indispensable to the engineer making aerodynamic flight calculations.

Effects of Real Gas Behavior

The changes in those properties of air referred to as real gas effects may considerably alter the equilibrium phenomena in the flow field outside the boundary layer. The first marked effect of the real gas behavior on aerodynamic phenomena is observed in the temperature obtained behind normal shock waves, as, for example, at the stagnation point on a blunt body. Since the amount of energy required to increase the temperature of air depends on the number of ways in which the energy can be distributed among the air components, the introduction of any new degree of freedom requires that more energy be supplied in order to achieve a given temperature rise.

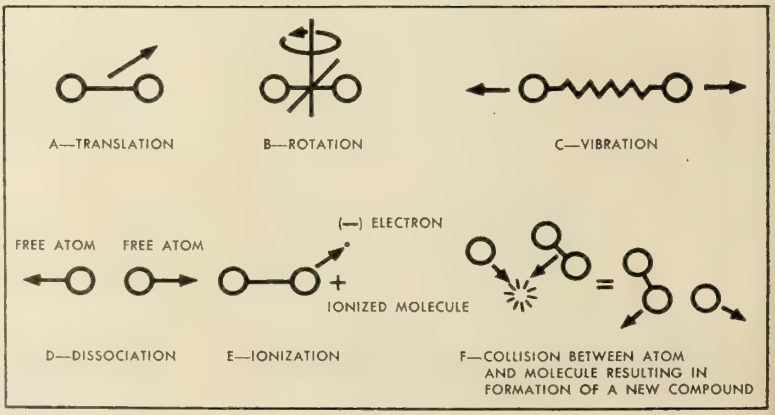


Fig. 1. The molecules of air in the hypersonic regime have a more complicated behavior.

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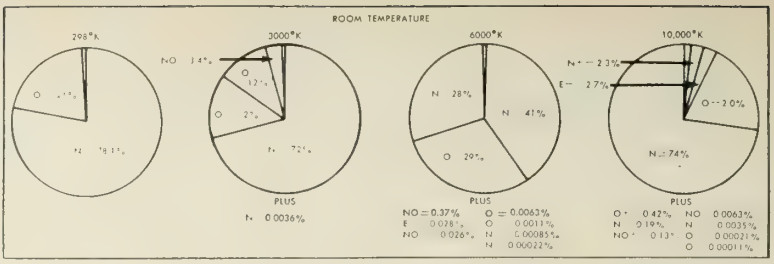


Fig. 2. Composition of high-temperature air (Density = one atmosphere).

Conversely, if there is a large number of ways in which the energy can be distributed, the gas temperature that can be obtained for a fixed amount of energy is always less in the real gas than in the ideal gas.

Consequently, the actual stagnation temperatures achieved behind normal shock waves is much lower than the temperature which would be calculated assuming that the air behaves as an ideal gas with a specific heat ratio of 1.4. The results shown are based on the assumption that thermodynamic equilibrium is achieved behind the normal shock waves; that is, that sufficient collisions have occurred so that subsequent collisions do not alter the thermodynamic state.

Another important difference between high temperature and low temperature flows at a given Mach number is in the shock angle on a wedge (Fig. 4). This is important because measurements of attached shock angles are commonly employed in determining Mach numbers in wind tunnels. At a given Mach number large differences in shock angle can result from the thermodynamic changes occurring in high temperature air. The difference is most striking for the wedge angle for which the oblique shock just detaches from a wedge. For real gas flows at high temperatures the oblique shock wave can remain attached for much greater wedge angles.

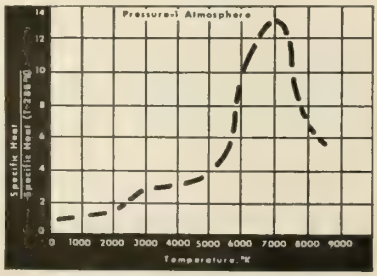
Lift and Drag Complications

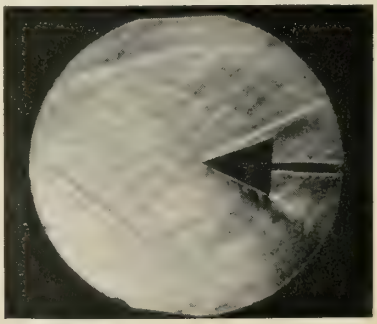
In two-dimensional steady flow expansions (known as Prandtl-Meyer flow), the actual flow Mach number increase across an expansion zone is smaller than would be calculated assuming ideal gas behavior. Fig. 5 shows that for supersonic flow expanding around a 20 degree corner the expansion zone is thinner, and the final Mach number is smaller than those obtained assuming ideal gas conditions. Since the pressure distribution over aerodynamic bodies is related to the flow Mach number, it can be expected that calculation based on ideal gas flow for pressure distributions over bodies will be inaccurate in high temperature flow fields.

As a final typical example, consider the effect of the real gas on the design of hypersonic test facilities. In the design of nozzles to obtain high flow Mach numbers, the nozzle ratio required in a real gas is much greater than the one calculated assuming an ideal gas.

The interpretation of data obtained in such facilities also is largely dependent on accurate calculation of tunnel flow conditions, since, as yet, the problem of measurement of temperatures and pressures in short-duration, high-temperature, low-density flows has not been entirely solved. However, before data obtained in these facilities can be reliably applied to full-scale bodies, it is necessary to learn much more about the air and its properties. One of the important problems being investigated at CAL deals with the actual state of the air in hypersonic shock tunnels. It has been assumed up to this point that the air in the high-

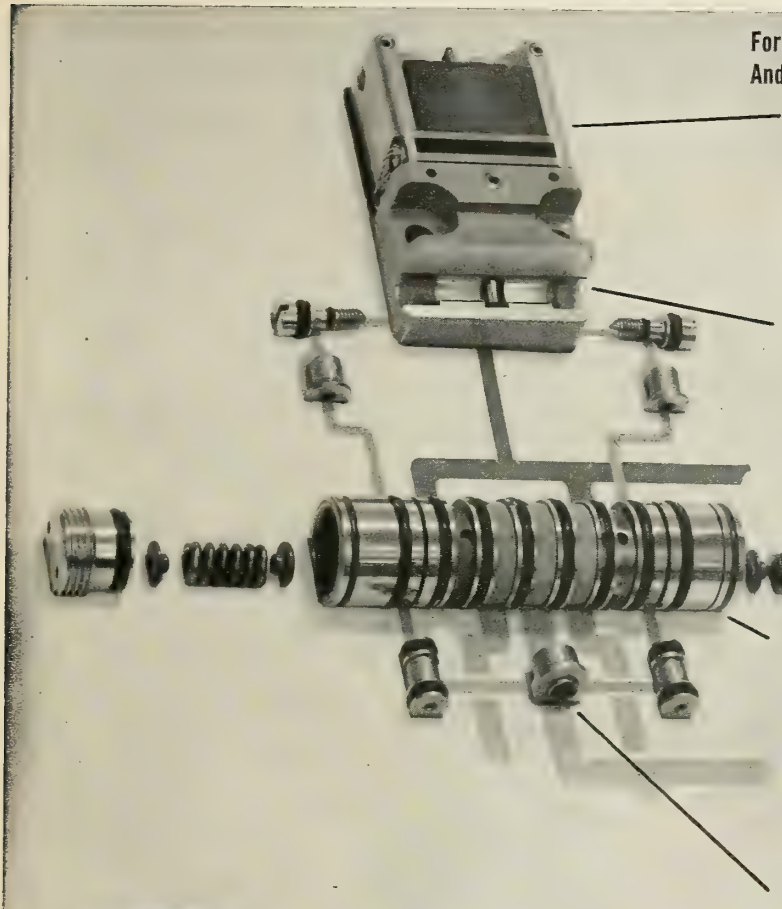
Fig. 3. (Below). Fig. 4. (Right).





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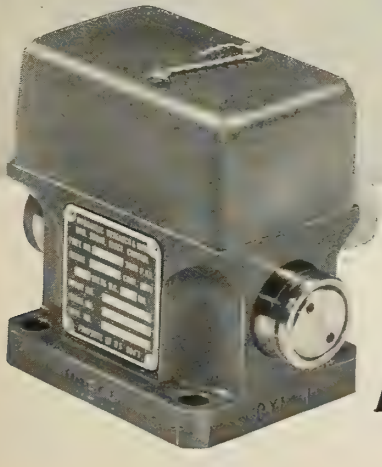
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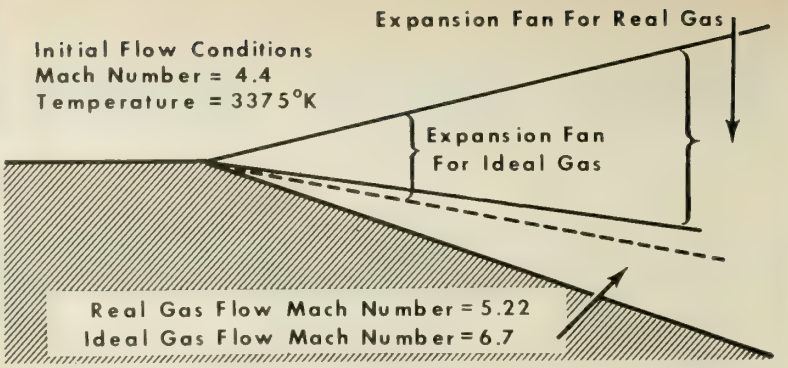


Fig. 5. Supersonic flow expanding around a 20 degree corner.

temperature region has attained the aforementioned state of thermodynamic equilibrium. Each of the forms of excitation shown in Fig. 1—translation, rotation, vibration, etc.—requires a certain number of collisions between air particles in order to reach the equilibrium state. A finite time, known as the characteristic relaxation time, is therefore required for equilibrium to be achieved.

Hypersonic nozzles must be designed so that temperature changes do not occur so rapidly that the thermodynamic state lacks sufficient time to adjust to the altered temperature conditions. Knowledge of the relaxations for the different processes are being carried out at CAL and other laboratories. Initial studies have indicated that it may be necessary to consider the relaxation time in the design of nozzles so as to insure that thermodynamic equilibrium is maintained in regions of rapid expansion.

More Answers Needed

Interest in the problems introduced by the high temperature phenomena has triggered many new fields of research. As an example, this interest has led to studies of the kinetics of nitric oxide formation and has stimulated the development of a special shock tube for the study of chemical reactions at high temperatures.

Only a few of the many new problems introduced by the high temperature air phenomena have been discussed here. There are many others—for instance, the heating produced by radiation behind a shock wave may have important effects at high flight Mach numbers. Such problems are now being investigated in special shock tube facilities at CAL. There is also a sufficient number of free electrons present in air at temperatures above 3000°K (or above a Mach number of 10) so that the conductivity of the air is high. This high conductivity may pose serious communication problems. Further, it is to be expected that the real gas effects may modify the boundary layer and heat transfer phenomena. For example, above 3000°K the air contains many dissociated particles and if these particles diffuse across the streamlines and recombine at the wall, the surface heating may be increased above that obtained without diffusion.

Consequently, aeronautical engineers are on the threshold of designing aircraft and missiles to fly through an entirely different medium—a medium whose ramifications are just beginning to be recognized and whose characteristics have been only sketchily explored. We call this medium a new air for engineers.★

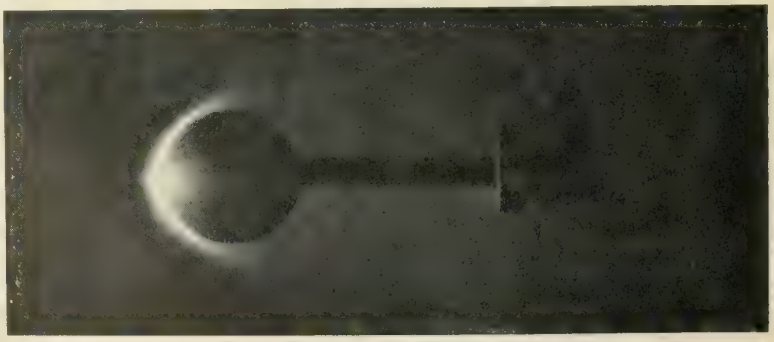
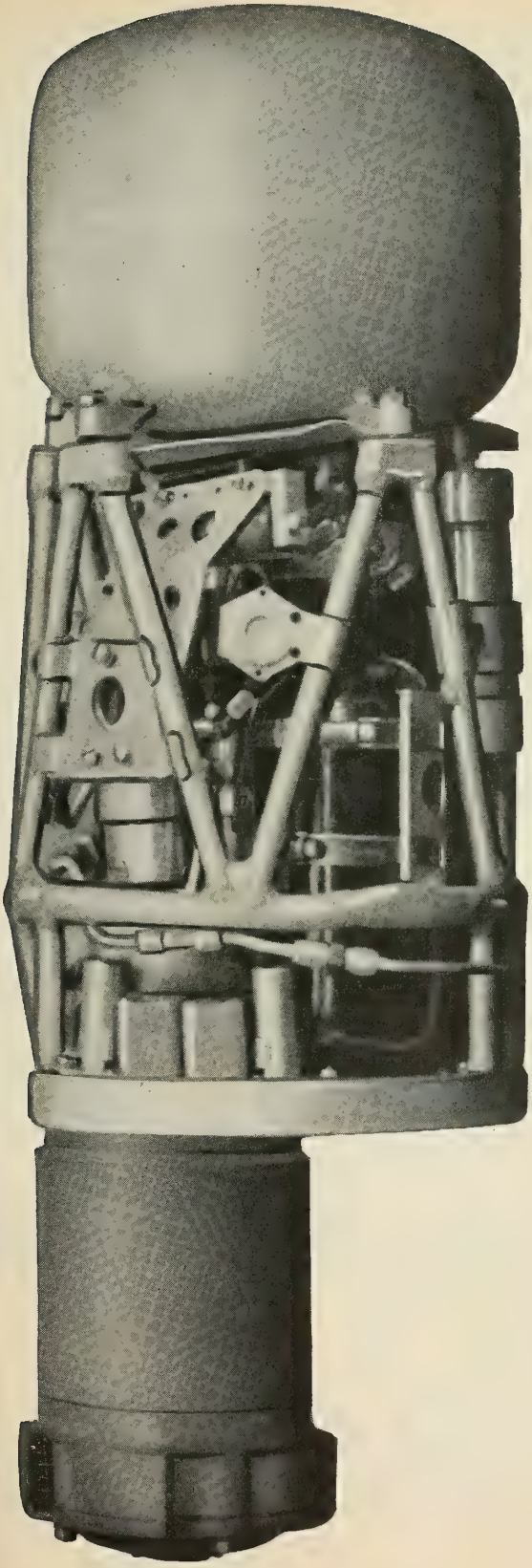


Fig. 6. Flow over a sphere in a hypersonic shock tunnel.



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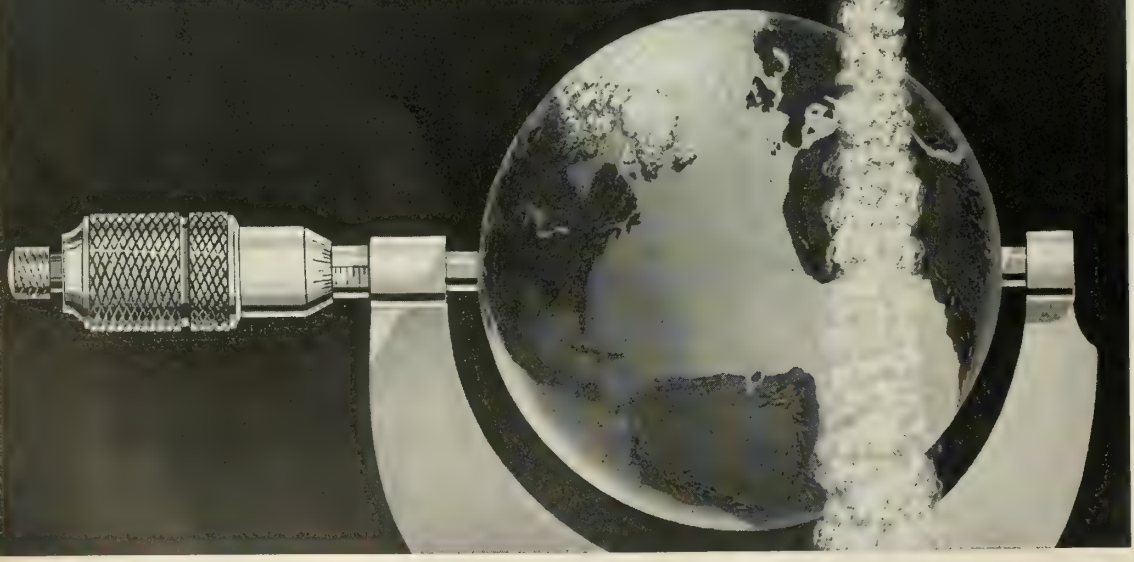
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Human Engineering for Space Vehicles

New field of engineering for astronautics era

By Cmdr. George W. Hoover
Office of Naval Research

IN THE PAST human engineering has played the role of patcher-upper and ex-post-facto adviser—an aeronautical Mr. Anthony. Today it is playing a very definite part in the design of modern aircraft and spacecraft. Component manufacturers as well as airframe builders are retaining human engineers on their staff or in a consultant capacity. The human element is at last being taken into account in machine design.

Tomorrow, with the coming of the spaceship the human engineer must move up to take his place in the design team, because space flight cannot be achieved unless maximum integration is effected between man and machine. Effecting this integration is the human engineer's job.

Human engineering, however, cannot play its part in achieving space flight unless it is fully accepted by all members of the design team. Some engineers have refused to recognize this new field and in some cases have been well justified. Like every new science, human engineering has had and is still having "growing pains."

Common Language Needed

Perhaps the most important reason for this nonacceptance is due to a language problem. Most human engineers are psychologists by training and have had to draw from the vocabulary of that field to create new terminology to communicate the results of their findings. This was necessary because they were working in new areas where such things as "JND" (just noticeable difference) and "learning curve" (the rate of operational improvement in a given task) had no equivalent in engineering vocabulary.

This, however, certainly follows the pattern of other fields—the continuous misunderstanding between engineers and physicists, electrical engineers and electronic engineers, and even physicists and nuclear physicists. There is always a period when the language of a new art or science is being rephrased in terms of an old one.

But in the space flight problem, the language required is new to all engineers, physicists and human engineers alike, and so the members of the team must seek a common language in order to be able to interpret their mutual problems.

In the design of aircraft, until very recently, engineers as a rule could expect the pilot to meet the control requirements generated by the machine. At the present time these same engineers are facing much more complicated problems because the machine is forcing the pilot to extend his capabilities to the limit.

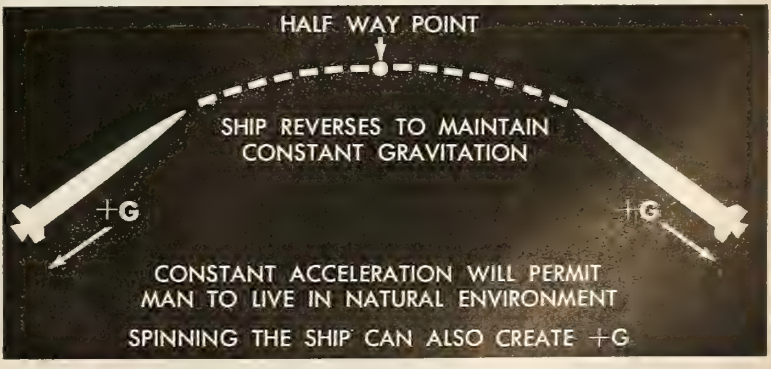
High altitude has forced the pilot to use oxygen equipment and pressure suits. High performance has brought about the need for anti-g suits. All of these require considerable training and demand that pilots be in extremely good physical condition. In the design of the spaceship the engineer will be forced to invite the aid of the human engineer because the machine's capabilities, by its very nature, will be far beyond the pilot's capability or physical limitation.

The spaceship will call for protection against extreme g loadings on the pilot due to the high thrusts which the ship may have to utilize. It will be necessary to protect against zero outside pressure in the event of loss of cabin pressure.

Because of the altitude the pilot must also be protected from cosmic and ultraviolet radiation, meteorite hits, intermittent weightlessness, and many other conditions abnormal to his ordinary pattern of living, all requiring definite procedures with no allowance for error. In space flight, just as in a submarine, there can be no mistakes, —but even more so, because the return to earth of a spaceship is more complicated than the return to the surface of the ocean by a submarine.

Man-Machine Interdependence

In space flight there must be as complete reliability as possible of both



Constant acceleration of vehicle eliminates problem of weightlessness in space.

man and machine. Both will be taxed to extreme limits.

If the spaceship is to operate successfully it cannot be designed by past conventional methods. Such methods might entail compromises of the total system which put an increased burden on either the man or the machine; and from past experience such burdens will undoubtedly be placed on the man.

In order to avoid any such compromise, the spaceship cannot be designed until a complete analysis of the problem is made and answers are found to such questions as these: What will man need to orient himself in space? How does man operate most efficiently under positive and negative g? What does man need to protect himself against extreme temperatures? Complete understanding is required of how man functions most effectively. Such an analysis can only be achieved by the joint efforts of engineers, physicists, human engineers and physiologists working as a team.

Human engineering is much more fundamental than experimental psychology and requires a thorough understanding of the way in which a man functions in order to determine his requirements when operating with a machine in a closed loop. Here the human engineer cannot accept what appears to be a reasonable answer, but must determine precisely what the man needs to operate efficiently and relay these requirements to the engineer.

Predesign Planning Vital

Generally, human engineers have been called into the design problem after the equipment has been designed and found to need improvement. They should be active in the establishment of the design requirements in order to insure compatability with the functions of the operator.

For example, the development of the space suit should have utilized the first signs of its need became apparent. services of human engineers when the Instead of this, the engineers were forced to design a suit to meet only the immediate problem with only partially adequate results.

The real task was to define the problem of how to create a proper environment to meet all conditions—not to attempt to solve it by designing a suit. A suit is only *one* way to create an environment, but unfortunately it does not meet total requirements, one of which is comfort.

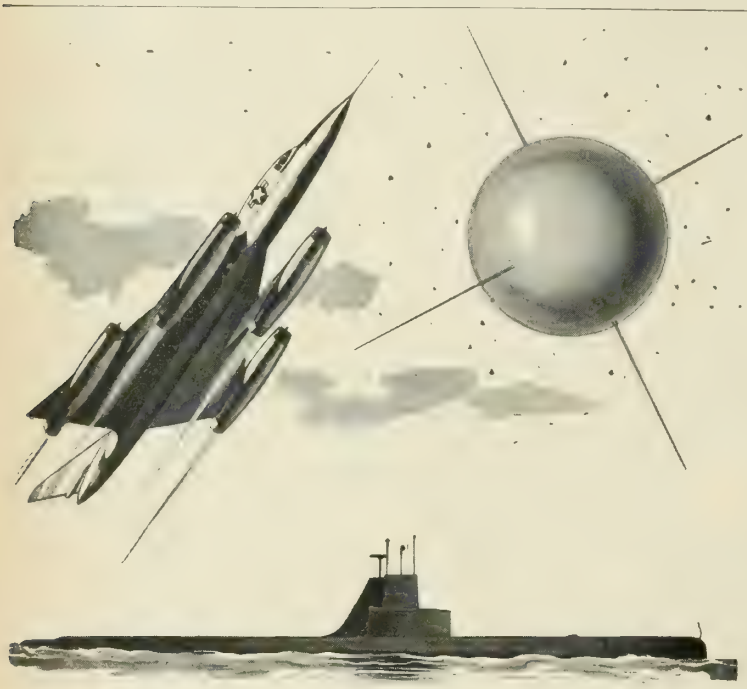
Problems of space flight must be approached properly in order that mistakes which may prove fatal will not be made. Human engineers must be brought into the team at the beginning in order to insure that equipment will be designed to meet the crew's requirements.

Take the problem of weightlessness. A great deal has been written on this subject and many schemes have been devised to study means by which it would be possible for man to live in this environment. Many writers have pointed out the problems involved—eating and drinking, sleeping, working. They have pointed out the necessity for physiological as well as psychological studies to determine what will be required in the way of equipment and training for crews of spaceships.

Weightlessness comes about when the ship stops accelerating and coasts, or during extreme changes in thrust. There is no requirement for zero acceleration other than that based on present day rocket capability which, by no stretch of the imagination, will be sufficient to permit manned space flight.

Man's requirements necessitate his living in a gravity system. This calls for a vehicle which will be in a constant state of acceleration or deceleration, not one which will force man to live in an environment to which he is unaccustomed. The only problem will be during changes in amount or direction of thrust.

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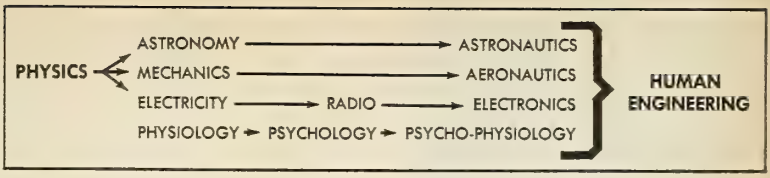
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which creates an entire family of new problems, or to design a system which eliminates the problem? A man cannot be changed—the system can be.

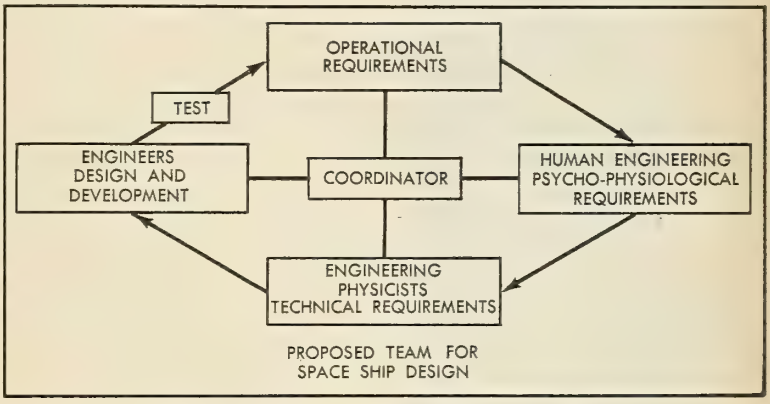
Engineers will state that even by extrapolating the state of the art to some future time, there is no foreseen propulsion method which can give constant acceleration during space flight. This will have to be found. Just as important as the requirement for temperature-resistant material for re-entry, just as important as the need for maximum thrust, is the fact that man cannot change his way of living. This is a man-machine system and the man is just as important as the machine.

Human engineering must be used and emphasized if manned space flight is to become a reality. With human engineering the focus changes—from how much radiation a man can take, to how protect him against any radiation; from how much sudden acceleration he can take, to how to propel the ship within the pilot's normal limits; from how much temperature a man can stand, to how to maintain a tolerable temperature.

Up to now pilots and crews have had to be given special training and equipment and have had to adjust themselves to the deficiencies of inadequate machine design. In the spaceship this is not acceptable.



"Family tree" of human engineering springs from many scientific fields.



Organizational chart shows the interdependence of all phases of design problems.

Space flight is not something mysterious or impossible. It is just another advanced step requiring an efficient man-machine system. It must be faced squarely, and this can only be done with human engineers working as a team with the design engineers.★

Opinions are those of the author. They do not necessarily reflect the views of the Navy Department.



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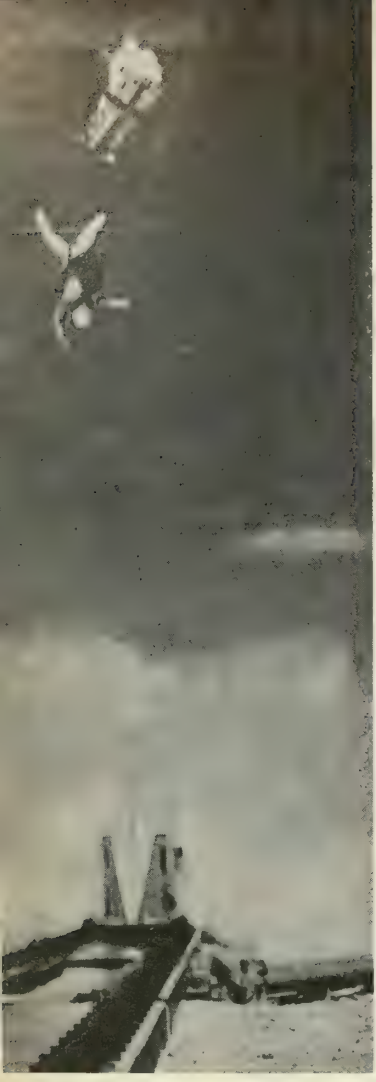
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Rocket Sled Experiments

By Alfred Zaehringer

ROCKET SLED testing has become a vital part of our missile programs. Aerodynamics, propulsion, structures and even human factors are being evaluated in this economical, captive and recoverable method. There are now five major rocket tracks in the United States and four smaller facilities. The big tracks and lengths are:

1) SNORT, China Lake, 21,500 ft.
2) Baker 4, China Lake, 14,000 ft.
3) Edwards AFB, 10,000 ft., expansion to 20,000 ft.
4) Holloman AFB, expansion to 35,000 ft.
5) SMART, Hurricane Mesa, Utah, 12,000 ft.

Smaller tracks are located at Eglin AFB; Aberdeen Proving Ground, Aberdeen, Md.; Naval Proving Ground, Dahlgren, Va.; and Redstone Arsenal, Huntsville, Ala.

Tracks Busy

There is a great backlog of work stacked up for every track. Speed records for these tracks have constantly edged up to keep up with the ever increasing speed of aircraft and missiles. The Coleman track, for example, qualifies at Mach 2 (1500 mph at track elevations) but recently SMART had an 1800-mph run. This high-speed SMART run was made with a 9400-pound vehicle which went off the track, over the end of the 1500-foot high Hurricane Mesa, and some one and a half miles into the valley below.

The highest speed attained to date is believed to be the 2180 mph attained by SNORT on a single rail sled with recovery at the end of the run. In a two rail run on SNORT, 1705 mph was attained. Holloman engineers believe that when their 35,000-foot track is completed, it may have Mach 4 capabilities for aircraft and missile testing. Edwards will have its 20,000-foot track finished in about a year. It is designed for Mach 4.

Grading on the Edwards site has been completed and digging and pouring the concrete foundation should start soon. The distinguishing feature

Left—Hurricane Sam flails wildly during an ejection sequence. Sled has just entered water brake and is about to hit arresting gear. Below—Aerial view of SMART facility at Hurricane Mesa, Utah. Breech end is at top. Test specimen hurtles over 1,500 ft. cliff at lower left. Track is 12,000 ft. long.



of the Coleman track, the 1500-foot cliff at the "muzzle" end, will keep SMART in the business of testing human escape techniques, essential in high-speed jet and rocket aircraft.

Survival Tests

The escape problem for high-speed aircraft still remains critical. Above supersonic speeds, only 20 per cent of the pilots can expect to survive during an emergency ejection. With increasing speeds and altitudes, the trend appears to be heading toward pods or capsules which will insure safety at ultra-altitude operations. Capsules eliminate the effect of air blast and also obviate the need for special suits and survival gear.

An ever increasing track function, on the other hand, is to test nose cones of ballistic missiles. It has been said that the major function of the longer tracks is to simulate heating problems of full-scale, nuclear warheads for the IRBM and ICBM.

Hot Slippers

One of the major problems associated with the present slipper-type sleds is friction. These shoes have to clamp over the rails to keep the vehicle captive at all times. Since vehicle weights are not very high and since the fast speeds mean only transient contact, present rails suffer only small wear at speeds of 500 to 600 mph. However, vehicle weights have been going up: full-sized escape systems, then entire cockpit sections.

Missile nose cones and warheads have also grown. Therefore, hot slippers are becoming a problem. Stainless steel has been successful here but increasing attention is being paid to the ceramics, ceramets and ceramals. There is also the hydrodynamic approach, which would eliminate any solid contact surfaces.

Solid versus Liquid

The old question of rocket propulsion systems—solid versus liquid—again cropped up. It was agreed that for sled propulsion the following conditions have to be satisfied: (1) performance, (2) economy, and (3) reliability. At present, solids are widely used because of their high utility. Solid motors often give the highest thrust per given cross-sectional area. This is especially important in track work, and therefore solid motors have become workhorses at most tracks. Everybody, too, is likely to agree that solids are much more reliable than liquids. However, economy, especially for high thrusts and repeated operations at these high thrusts, may dictate going to liquids.

It would be more economical, for example, to couple 10 18,000-pound solid RATO motors for a few runs than to develop an 180,000-pound-thrust liquid motor (or two 90,000-pound engines). But, if you have a hundred or a thousand tests at 180,000 pounds, it may pay to develop a liquid engine. The Coleman track, because of its remote site, has heretofore operated exclusively on solids, but has just taken delivery on two Aerojet acid engines of about 50,000-pounds thrust.

As one track man put it, solid motors make nice modular units and allow great flexibility in arriving at almost any thrust level. Too, solid motors, having been loaded at the factory, are time and personnel savers, letting the track concentrate on the testing.

The SMART track has used six different solid units with great success. Coleman has a stockpile of now-obsolete *Loki* rockets for smaller vehicles. HVARs have also been used. Two of the most commonly used units are the 2.2KS-11,000 and 5KS-4500 RATOs. Two of the larger units are the T-50 booster and the 224-B made by Hercules Powder Co. ★

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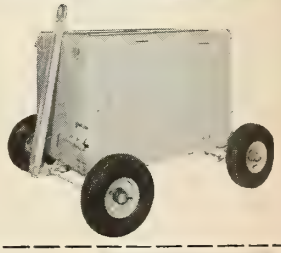
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Propulsion Engineering



By Alfred J. Zaehringer

ROCKETS VERSUS BALLOONS. Performance of both vehicles is surprisingly similar, according to High Altitude Test Division at Holloman. The balloon has lifted 1300 pounds 76,000 feet high (98.7×10^6 ft/lb) while an *Aerobee* has lifted 154 pounds some 119 miles (97.0×10^6 ft/lb).

BURNING RATE OF NITRIC ACID PROPELLANTS has been studied at USNOTS, China Lake, Calif. With 2-nitropropane and 90-100% HNO_3, small changes in acid concentration (near 100%) cause large changes in consumption. This "low pressure step" is said to be related to the surface temperature of the burning liquid. Turbulent combustion is related to acid concentration and the number of carbon atoms in the fuel.

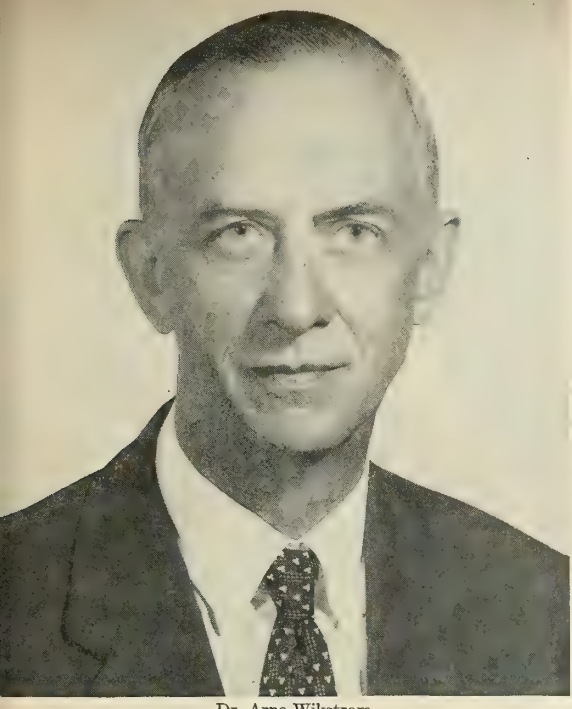
NEW PERCHLORATE. Nitrosyl perchlorate, $NOClO_4$, has been found to be quite stable in the anhydrous state. However, research in progress at the University of Amsterdam shows that the compound can be exploded by ultraviolet radiation.

BORON FUEL RESUMÉ. After 11 years of research, NACA finds that general combustion performance of the hydrides is good. Handling and storage are problems but not impossible to solve. Big problem is the formation of boric oxide on combustion. At 1000-2000°F B_2O_3 is a solid, but in the 2000-4000°F range it is a messy, syrupy liquid that clogs up hardware. This crudding is especially bad in turbojets, which may restrict it to special engines or to afterburners. However, NACA has successfully flown a pentaborane-powered ramjet. On the other hand, the Lewis Lab is disappointed in its results with metallic boron-jet fuel slurries: high combustion efficiencies could not be achieved at high-altitude conditions.

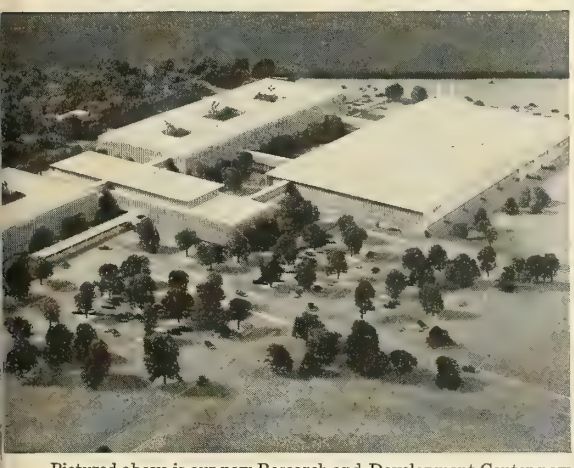
HOKO CONCENTRATED NITRIC ACID PROCESS is now being introduced to the United States. The Pintsch-Bamag process produces the 98-99% pure acid directly and can also produce nitrogen tetroxide, nitric oxide, RFNA or any concentration of nitric acid. Raw materials for 100 tons/day of 98-99% acid are 29 tons of anhydrous ammonia and 17 tons of oxygen.

LITHIUM DEUTERIDE may be under study as a fusion rocket propellant. Small amounts fed into a combustion temperature heated to 4000-7000°F would generate large amounts of heat which could be used to expand the helium gas exhaust product. Nine grams of LiD would liberate 4.3×10^{20} ergs. However, two of the big problems are diluting the stream to keep down temperatures and yet maintaining a self-sustaining reaction and adjustment of the proper feed rate.

METALS FOR ROCKETS. Satisfactory oxidation resistance for molybdenum still hasn't been attained. Tungsten might provide another 300-500°F increase but its oxidation resistance is also poor. Columbium may, however, provide another temperature increase.



Dr. Arne Wikstrom



Pictured above is our new Research and Development Center now under construction in Wilmington, Massachusetts. Scheduled for completion in early 1958, this ultramodern laboratory will house the scientific and technical staff of the Avco Research and Advanced Development Division.

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Dr. Arne Wikstrom
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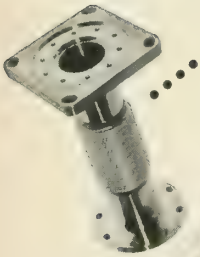
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Ultimate Weapon: The Mind of Man

By Tom Wilcox

Air Force Office of Scientific Research

THE SIZE, force and shock action of a military machine are formless, useless capabilities without the supreme motivation, guidance and intuitive genius of the mind of man. In the military affairs of our nation, as in all other endeavor, the study of science alone—without a clear understanding of the implications of its findings—can result in the enervation of man's progress. The finding of a principle or a thing is no more important than the recognition of its implications.

The Air Force Office of Scientific Research, Air Research and Development Command, provides a mechanism for daily translation of this philosophy from words into action. Scanning constantly all areas of industrial and scientific research, it seeks, finds and supports investigations which help to keep the Air Force in a position of technical and strategic superiority.

It has been said that the Air Force scientist is working the aviator out of a job; that research and development effort leads inevitably to only two possible conclusions: the removal of man from the aircraft and the development of the ultimate in destruction.

The first of these statements is neither inevitable nor desirable; the second is only partially correct. If it were true that science is taking the pilot out of the combat picture, we should view this as tragic and dangerous.

For science to serve the ultimate ends of the military mission, it must insure that the mind of man will, in some way, influence and control every weapon system we create.

To subordinate the intellect of a military commander to a synthetic complex of electronic gadgetry would be to deprive that commander of the imaginative and intuitive genius which has always led to victory in battle. Engineers and technicians can produce many types of computers which will rapidly calculate the most complex mathematical problems. They can provide them in many shapes and sizes. They can place them on the ground or fly them. With them, we can control speeds and altitudes. We can use them to navigate and to drop bombs or fire missiles and bullets.

But computers are unemotional. They cannot think. They do not reason. They need no food, or any stimulus other than the power which feeds their circuitry. They cannot be motivated to performance beyond that which has been punched into them, nor can they be trained to take advantage of an unforeseen circumstance or to change course in the light of unpredictable conditions. In short, they are nothing more than morons—and *wars are not won by morons.*

The history of warfare has been compared to a balance. The evolution, development and employment of new weapons tip the scale forcibly toward the side which has evolved the new concept. However, each new measure stimulates countermeasures which, if effective, balance the scale. To weight the balance to his own advantage the commander must do two things: first, he must employ his forces so imaginatively that, despite the equality and strength of his force and that of the counterforce, the imaginative commander quickly and successfully achieves his objective while the countermeasures result only in striking at phantoms.

The second factor for successful command is the ability to recognize and use the full capability of one's own resources. The creation of imaginative concepts of warfare and the recognition of our full capability are the mission of the Air Force Office of Scientific Research, and its unique contribution to the United States Air Force. Weapons which we are evolving today came from recognition of scientific discoveries of the more or less recent past.

Recognition of decades of exploratory research by inspired mathematicians and physicists led to our World War II Manhattan Project. This gave us the first use of atomic energy in war and, in turn, our present nuclear fission weapon systems and industry.

Germany's work on the V-2 rocket stemmed from military recognition of the early exploratory efforts of a small group of pioneer rocket experts.

The Air Force Office of Scientific Research role in support of basic research is unique. The Air Research and Development Command has 12 major activities concerned with developing and testing weapon systems and supporting research aimed at solving the problems of weapon development.

AFOSR builds no missiles, no rockets, no aircraft. Its program is concerned entirely with sponsoring the most basic exploratory work. The AFOSR program is designed to serve as a focal point within the Command for contact with university and industrial scientific research groups in all parts of the free world.

By communication and support of these scientists, AFOSR encourages them to bring to its attention entirely new concepts and capabilities. Some of these new concepts will eventually result in forming a basis for the development of new weapon systems and concepts for their employment.

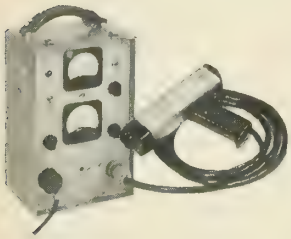
AFOSR does no actual laboratory work within its own organization. It serves as a vantage point for scanning all scientific areas and supports by contractual means those which offer the greatest promise.

Some of its programs might seem far removed from military application. For example, AFOSR might investigate the magic substance chlorophyl, the chemical which, by photosynthesis, converts the carbon dioxide in the atmosphere to life-giving oxygen. This may have important future military application.

A future spaceship may depend on a closed environment to sustain life. With present techniques we would have to carry large quantities of oxygen and equipment in order to breathe. The quantities required, of course, would be governed by the time we kept the craft aloft. So it becomes obvious that an ability to regenerate our enclosed atmosphere would have a direct bearing on range and altitude. In aerial warfare these are essential factors of tactics and strategy and may actually determine whether we will be victorious or vanquished in some future war.

The Air Force search for scientific implications might be likened to a ground-force commander's study of terrain seeking to find the vantage points of high ground and maneuver area. AFOSR and its mechanism rep-

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resent the Air Force's search for the high ground and maneuver areas in science. We must have this capability. Our potential enemy has it and backs it with resources far more extensively than we do.

Certain fields of investigation receive financial support which is no more than that required to buy two or three ordinary military trucks. The results of any one of these programs may save us millions in lives and dollars.

Research and development in the basic technical fields are among the most important investments being made to insure a safe, bright and prosperous future.

We cannot insure this future unless our support is sufficient for the task at hand—the job of searching, recognizing and supporting all scientific areas of military interest.

The need for resources is high. To exploit all areas properly, the support of exploratory research must be augmented.

A current need is for leaders of the financial and industrial world to join forces with the military in a strong partnership for support of scientific research aimed at providing the strongest, fastest, highest Air Force in the world.

We need to go higher and faster. There is a future requirement for a satellite or a platform in space. The pages of history are filled with the names of commanders who were beaten in battle by rocks, spears, arrows or shells hurled from heights they had considered impossible to scale. To scale the heights of science requires no less measure of courage, imagination and tenacity.

These two things we know: our fight for a dominant technological position must continue in full force; and we must not negate the judgment of man if we are to succeed.

We can send into space a platform for observation. We could instrument this platform to relay to us a great deal of information. But, no matter how fully we equipped it, we could still miss the basic ingredient of useful surveillance: the instant and meaningful interpretation of important data and the ability to initiate prompt action of a command nature.

Soon after man started to use the airplane as a combat observation post, someone tried to shoot it down. In short order, two men were aloft and shooting at each other. Thus evolved a completely new military dimension.

We are on the point of introducing another new military dimension as important and revolutionary as aerial warfare was a generation ago. Manned space flight and observations are within the foreseeable future, and it seems clear now that there will be uses far beyond observation. It also seems clear that, if we should put a device in a predictable orbit, it would be only a matter of time before someone tried to shoot it down. The optimum weapons system still must be guided by the unpredictable and random output of a man's imagination.

If we would insure technical victory in the present race for survival, we must mobilize all the human imagination and ingenuity in our entire storehouse of science. We must apply our findings to a complex of weapon systems in a manner which insures that they are only the useful servants of a commander, not his master. We must evolve weapons which can be employed in the unpredictable pattern of the human mind, rather than the cold, set logic of a machine. In the final analysis, it is the proper combination of man and weapons that wins wars—cold or hot.

By careful recognition and employment of our scientific input, we can insure that the order of battle will be the influence which directs the weapon. We must not build ourselves an arsenal which will direct or influence the order of battle. Much of our current effort is directed to the building of missiles. They currently deserve top priority. We must have the best possible as soon as we can.

It would be dangerous, however, to think of the missile as the ultimate end of weapon development. Countermeasures to stop missiles and means of detecting them will surely follow. We must accomplish two things: we must build missiles and missile countermeasures and, at the same time, strive for new concepts which will take their place when enemy countermeasures reduce their effectiveness.

We cannot safely assume that simply placing bigger bombs on predetermined targets will insure the final victory, or that a fixed or static defense machanism can stop the forces of an imaginative enemy. Such assumptions can well lose us a war, the nation, the American way of life.

The great strength of American arms has historically been augmented by the quick, imaginative flexibility of its manpower, from general to private. In the process of scanning our world of science, and developing and employing our arms, let us always remember a brief pasage by the contemporary author, John Steinbeck: "Our species is the only creative species, and it has only one creative instrument—the individual mind and spirit of a man. ★

The views expressed in this article are the author's and do not necessarily reflect those of the U.S. Air Force.



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Nutrition in Space Flight

By Dr. Carsbie C. Adams

National Research and Development Corp.

ONE OF THE BIGGEST problems of space flight is nutrition. How is the crew adequately fed over a long period with the extreme limitations of space? How is nutrition affected by pressure, zero gravity, radiation and the inevitable psychological reorientation?

Studies to date indicate that there are no serious obstacles to nutrition in space if the individual is in good health. Digestion should not be adversely affected if the ambient pressure is not so low as to produce a physical and nervous strain to the body generally.

The matter of spaceship cabin pressure raises the question as to how great a compromise can be made with sea level conditions for long-duration exposure.

There are reports that the feasibility of zero gravity has been established. This would seem to solve the major problems of orientation as related to nutrition.

Since the exact nature of cosmic rays' origin, density and composition have not been completely established, we can only speculate on certain close similarities to conventional atomic radioactivity. One is left with the supposition that a sufficiently strong cosmic flux will induce anemia and possible leukemia. The latter disease would be quite beyond the restorative powers of nutrition.

Pressure

There has been no direct evidence of a relation between nutrition and pressure except from the view of dietary results where food has apparently been consumed in normal ambient conditions and prior to flight. However, the WADC Report 55-353 reveals some potentially useful information: a high carbohydrate meal before ascent (15,000-17,000 feet) increased both altitude tolerance (by 1000 feet) and psychomoter performance (by 2000 feet).

Adult male rats on a vitamin B_1-deficient diet for two months showed a greater resistance to lowered barometric pressure (34,000 feet) which was decreased to normal in one to three hours after supplemental thiamine feeding. However, a two-to-five month subminimal-thiamine diet seems to have no effect on man's altitude tolerance.

There is a more rapid loss of alcohol from the blood at 12,500 to 16,000 feet than at ground level. The most rapid loss of body water from adult rats at 15,000 feet occurs during the first eight hours of altitude exposure.

For the first 48 hours thyroid activity of unacclimatized rats is noticeably decreased at 11,500 feet and is accompanied by a sharp drop in rectal temperature for the first 12 hours of exposure. Thiouracil (anti-thyroid substance) taken for from four to 35 days does not affect the altitude tolerance of man at 32,500 feet.

Daily three-hour exposures to a simulated 12,000-foot altitude produced no significant change in appetite, gastrointestinal absorption, adrenal cortical function, sodium and chloride balance, urine volume or ketosteroid excretion.

The respiratory rate of an experienced pilot in action is directly related to the complexity of a given task.

Cabin pressure in a spaceship may not be equivalent to that in terrestrial craft. A typical airline cabin is set for 8000 feet pressure equivalent, just below the altitude for physiological effects.

Experience may reveal that tolerable pressure drop is an inverse function of duration.

Appetite may be influenced by mood. It has been demonstrated that eight hours at 10,000 feet induces "boredom, incoordination and headache."

Elimination at tolerable pressure reductions would either be unaffected or slightly aided. The body as a whole will eventually assume the pressure of the environment and thereafter the effect of pressure on elimination one way or another is negligible or zero.

Ingestion should not be adversely affected at any pressure which the unprotected body can endure. The pressure at which water would erupt (boil) at ambient temperature would kill the body by explosive decompression.

Susceptibility to anoxia (17,000 feet for two hours) may be reduced by a high-carbohydrate diet prior to ascent. Administration of glucose did not alter the susceptibility of rats to the acute effects of anoxic anoxia (4.5-5.6 per cent O_2). Glucose ingestion 30-50 minutes before flight prolongs consciousness time with high-altitude anoxia (27,000-30,000 feet).

The ingestion of 50 grams of glucose one half hour prior to altitude (12,700-17,200 feet) ascent decreased the intensity thresholds for vision at those altitudes. This is attributed to the elevated blood sugar. Cortico-retinal function (peripheral vision) and psychomotor function (block placement) tests indicate that significant gains in altitude tolerance (15,000-17,000 feet) can be achieved by ingesting high-carbohydrate foods before and during flight. With partial inanition, there is also an increased hypoxia tolerance due to lowered oxygen requirements.

Nicotinic acid increased the minimum survival altitude for rats by 4525 feet. Vitamin C does not affect consciousness duration in man at 27,000 to 30,000 feet. Oral vitamin E increases anoxic anoxia survival time in adult rats; mitigation occurs if the diet contains more than 12 per cent fat. Vitamin E similarly affects the rabbit. Iron supplementation in rats does not increase hypoxia tolerance at 20,000 feet.

No direct connection between appetite and oxygen has been found. Any deviation from normal sea level oxygen content in space would tend to be in the direction of hypoxia. Use of 100 per cent oxygen, except in case of emergency, would be an extravagance. The reduction of body temperature, associated with hypoxia, may demand or create the imaginary requirement for additional food, disregarding the influence of the lesser exertions of free-fall, if present. It may be expected that a modeate hypoxia of sufficient duration could be psychologically depressing and would adversely affect the appetite.

No connection between oxygen content of the cabin breathing mixture and the processes of ingestion, digestion, and elimination have been encountered in current literature.

Zero Gravity

Work is now in progress on the relationship between nutrition and zero gravity. One aviation magazine confirmed that "experiments related to the

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space travel regime have established the feasibility of eating and drinking during a condition of weightlessness. The studies, conducted by the School of Aviation Medicine, Randolph AFB, Texas, employed a Lockheed F-940 following a parabolic flight path that afforded interludes of weightlessness as high as 45 seconds."

Earlier reports which considered the possibilities of adverse effects due to disorientation were pessimistic. It was thought that vertigo, induced by disorientation, would create a situation making digestion all but impossible.

The element of appetite in this respect would seem to be related to individual adaptability to the situation. Flights in the X-1 and X-2 airplanes suggest that vertigo would not appear if the pilot kept his eyes open and thus maintained the visual element of the orientation trial. Compensation presumably kept the orientation from collapsing altogether.

Ingestion would not present serious problems insofar as valve action of the body is concerned. Food placed in the mouth would be retained by the confining action of closed lips. The main problem apparently is preingestion status of the nutritive material. Solids may be confined by their structural nature (as in sandwiches) or by continers, and liquids introduced either as part of the solid material or administered by squeeze-type bottles.

Liquids and solids, reduced to a paste-like consistency, may require some help from the tongue to move them into the esophagus. This skill should be acquired with a minimum of practice.

Digestion, including the later-phase process of assimilation, runs into the problem of digestive fluids dispersing into foam, and may, according to Buettner, tend to isolate the food material to be processed from the peristaltic agencies of the alimentary tract.

The solution here appears to be the inclusion with the food of a defoaming agent which is compatible both with the food and the organs of the body performing the various digestive processes. No data has yet appeared on these, but no serious problem is evident at present.

The only problem in elimination is disposal. Special toilet installations, or some such local device as centrifugation, might solve this.

Radiation

Two types of radiation hazards must be considered as cumulative in their effects. No impediment to appetite, ingestion, digestion, assimilation or elimination is known in the sense of immediate effect.

One major source of radiation likely in space is bombardment by cosmic ray particles.

Cosmic radiation may manifest itself in two ways—action on food and action on the body. Buettner says categorically that "radiation hazards to food may be safely excluded since cosmic radiation in this respect is completely harmless." This is not surprising on reflection, as radiation using atomic energy is currently contemplated. The scientists seem to be very confident of the general feasibility of the idea and are worried mainly about such groups of food as dairy products, which stubbornly resist irradiation processing for preservation.

The effect of cosmic radiation on human beings is another matter, because the impact of particles on cellular components, notably nuclei, is thought to be quite capable of pathological effects. The difference of opinion on the matter is somewhat curious. The only thesis the optimists can defend is that the radiation intensity has been greatly overrated.

If there is division of professional opinion on so basic an aspect of cosmic radiation, there is not much hope for a concise description of general cosmic radiation and its specific effects on humans. To treat it as analogous to atomic radiation, with certain obvious exceptions, seems logical, but not more than this can be said at the present time. Cosmic ray biologists are still determining the best type of specimen to send aloft.

One is left with the cautious supposition that cosmic ray sickness will manifest the same symptoms as atomic radiation sickness, and thus have the same effects on the alimentary processes. Human tolerance to gamma rays is about 0.5 roentgen.

Overirradiation produces vomiting, then fever, diarrhea, weakness and progressive anemia. Hemorrhages result from impairment of blood-clotting mechanisms. The reduced white blood count would handicap the victim in event of exposure to disease. Space flight may be harmless, hazardous or suicidal, depending on the flux density.

Careful Selection

It is assumed that the crew has been carefully screened for emotional stability and general good health, using the same high standards as in the selection of jet fighter pilots. It is further assumed that sanitation and toxicological hazards have been taken into account in the design of the ship.

Nutritional substance must be adequate in quantity, well balanced, palatable and provide adequate body energy. Adequacy of quantity requires extreme compactness. Some improve-

ment along this line has been noted in conventional food merchandising, notably in frozen foods, dehydrated products and sometimes in the techniques of meat cutting. This is not enough for the logistics of space flight.

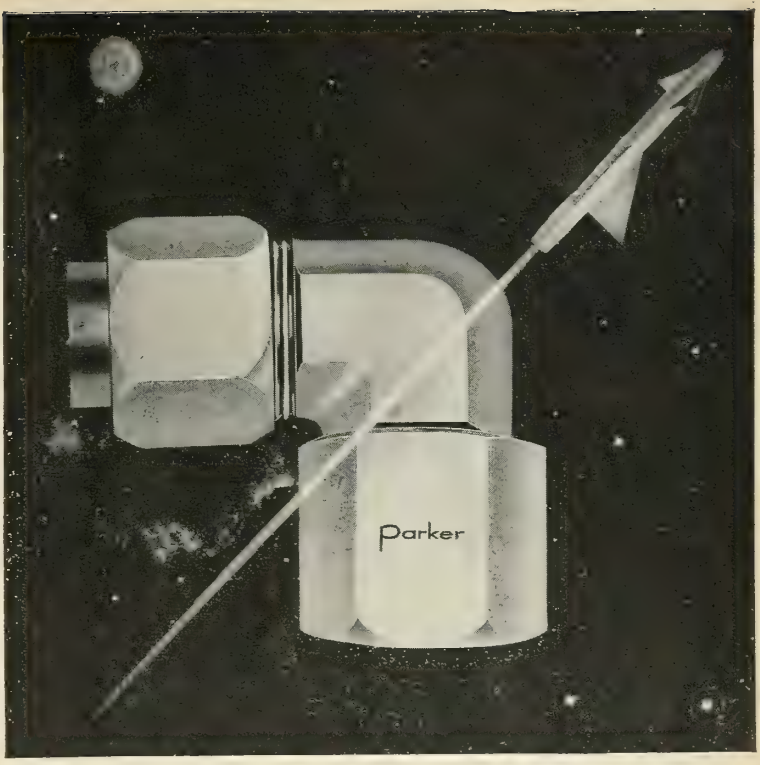
Some effort has been devoted to tabletized and other forms of concentrated nourishment. There are two opposing schools of thought on whether or not the body can safely survive with bulkless food. One school maintains a certain minimum is required to maintain conventional gastrointestinal peristalis. The other school points to the fact that the body accumulates and voids itself of waste long after the last food ingested has been eliminated. However, there is no record of an experiment where subjects attempted to subsist completely on superconcentrated foods and water alone. Meanwhile, it would be folly to assume that bulkless, tabletized foods can be trusted for long sojourns into space.

Another aspect of the nutrition problem is preservation, which often requires refrigeration and always asepsis. Food kept outside the vehicle and in shadow will be adequately refrigerated, and space is certainly sterile. A food product or concentrate which required neither would be very convenient.

Algae has been advanced as a food substance and is presumably fairly rich in carbohydrates. The present state of the art indicates a good start, but algae is not yet at the point where it is a very serious contender to other forms of food except insofar as it does regenerate itself. The Arthur D. Little Co. has in operation a pilot which measures 600 square feet in area and with 1200 gallons of culture produces somewhat over 0.75 pounds of dried algae per day. The quantity of useful food substance from this has not been determined, but is surely not 100 per cent. Even if it were, this is hardly enough to provide adequate nutrition for human beings even with a zero margin for error. If the vehicle is sufficiently large, it might help in providing part of the daily requirements.

Palatability complicates the nutrition problem and algae does not stand out in this respect. It does not whet the appetite nor encourage ingestion in the average person. Artificial preparations have an advantage here, as palatable additives enhance the overall acceptability.

What remains is a synthetic food concentrate, which is light, compact, balanced, palatable and requires little or no refrigeration or post-packaging asepsis. Concepts on nutritional adequacy will have to be altered to fit the needs of space flight. ★



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Progress in Space Medicine

By Maj. Gen. Otis O. Benson, Jr.

Commandant, School of Aviation Medicine

THE LARGER portion of the atmosphere, from the standpoint of human flight, is not unlike interplanetary space, if we ignore some conditions caused by the presence of the solid body of the earth itself. This knowledge makes us realize that space operations in the form of space equivalent flights are here and are of immediate interest to the Air Force.

In the *preliminary* phases of space operations most of the medical problems are encountered as they most probably exist in the *more advanced* and *final* phases of space operations, such as in interplanetary space travel. The main difference is the duration of the flight.

One of the most important medical considerations is engineering of the cabin of a space vehicle from the standpoint of human factors. This must be a development of close cooperation between the engineer and the biomedical scientist.

The cabin, of course, must be completely sealed. It is interesting to note that such a space cabin is required at altitudes as low as 70,000 to 80,000 ft. This cabin is not pressurized by the use of outside air, but rather must be pressurized from within —a self-sustaining system. It is the task of Space Medicine to provide the crew with the best possible artificial atmosphere providing adequate barometric and oxygen pressures. Removal of carbon dioxide produced by the crew in respiration is of special importance.

Other problems include humidity control, temperature control and odor removal. The magnitude and complexity of these technicophysiological problems require careful experimental studies in the laboratory.

On the vertical frontier opened by the rocket, human factors will play an important or even a decisive role. The medical problems involved in rocket or space operations are the subject matter of Space Medicine, a branch or an extension of Aviation Medicine. During the nine years that Space Medicine has existed as an organized entity, considerable progress has been made in both theoretical and experimental considerations. Here, briefly, is an updating.

Such studies are possible in experimental hermetically sealed cabins, such as the so-called space cabin simulator at the School of Aviation Medicine. This experimental device is different from altitude chambers where body reactions under decreased air pressure are studied. In contrast, task of the space cabin simulator is to *take care* of its occupants. Considerable progress has been made in this research field.

A Lesson From Plants

Experiments have been carried out for periods up to 24 hours under normal barometric conditions, and for a number of hours under reduced pressure corresponding to an altitude of 24,000 ft. Similar studies have been done in sealed gondolas for high altitude balloon flight at the Aero Medical Field Laboratory at Holloman AFB.

In space operations of longer durations, the scope of the problems will increase. New methods for the regeneration of cabin air may become necessary from the standpoint of economy. One means to accomplish this is the production of oxygen and removal of

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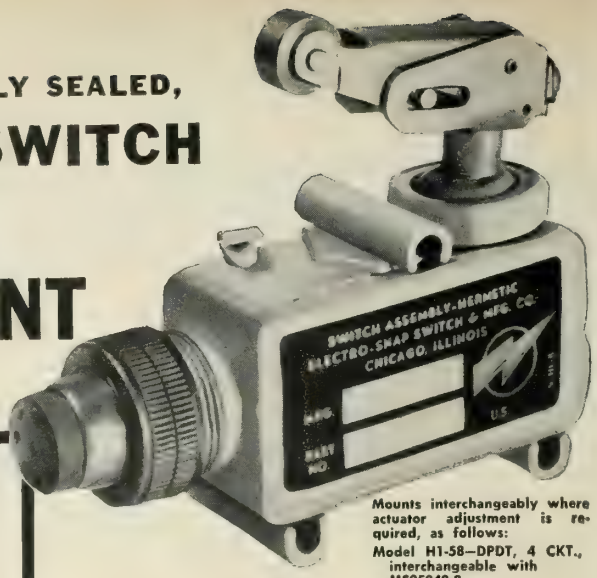
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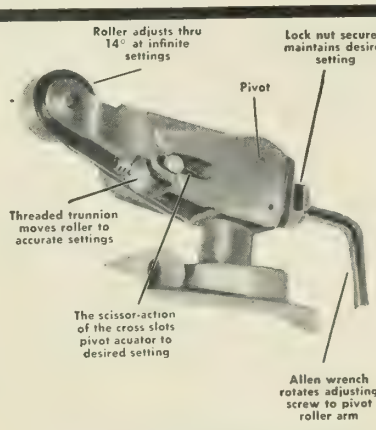
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carbon dioxide with the aid of photosynthesis as it occurs naturally in plants.

In experimental studies sponsored by the School of Aviation Medicine and carried out by Dr. Jack Myers, head of the Department of Algal Physiology, University of Texas, it has been found that five pounds of a species of alga are sufficient to supply the respiratory requirements of one man. These studies are being pursued and more data are being obtained.



Maj. Gen. Otis O. Benson, Jr.
Commandant, School of Aviation Medicine

Of course, in space equivalent flights and space operations of short duration, we will never resort to such a photosynthetic gas exchanger because of the weight and volume of such a device. For space operations of long duration it might be a different story; and under such conditions, the elimination and reutilization of waste products may become necessary. Developmental studies in this direction will make the scope of the physiological problems involved in a closed ecological system complete.

Problems of another nature, such as the psychological behavior in closed systems, will also enter the picture. Such studies are under way.

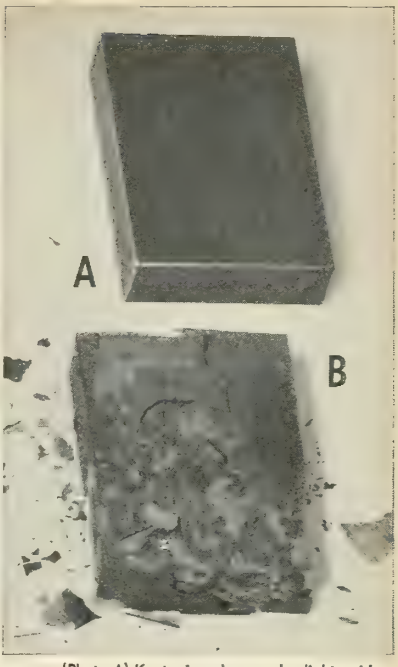
External Protection

A space cabin also must be equipped to protect the crew against external factors, such as meteorites and cosmic ray particles. Here is a fruitful field for close cooperation between the astronomer, astrophysicist, engineer and the bioscientist.

Insofar as cosmic rays are concerned, we are much better informed today as a result of theoretical calcula-

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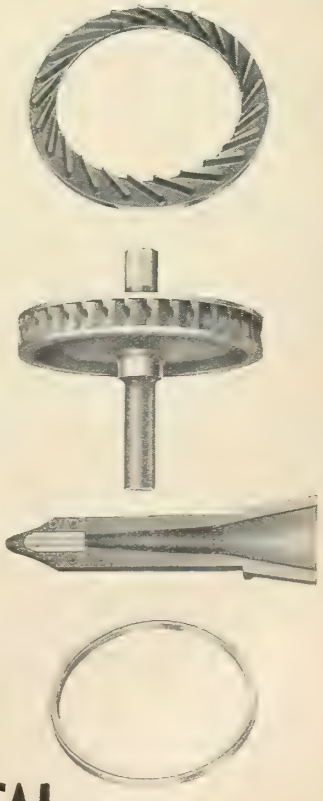
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Space cabin simulator used at Randolph AFB to study human reactions.

tions and experimental observations from high altitude balloons. For short-time exposure at altitudes where the primary cosmic rays are encountered, the situation is less dramatic than was thought some five years ago. With regard to flights of long duration, however, the question of health hazards from exposure to cosmic rays remains unanswered.

In the experimental sealed cabin we can simulate a number of space flight situations; but one condition that can hardly be produced in the laboratory is that of the state of weightlessness. Comparative studies have been made in a swimming pool, in which some of the features of weightlessness are achieved.

For a more complete understanding of zero-gravity and its biological effects during actual flight we must produce the "real thing"—namely, weightlessness in flight.

The method of producing weightlessness in parabolic flight maneuvers in jet planes is now pretty well understood. Control systems have been developed and a significant number of experiments have been carried out at the Aero Medical Laboratory, Wright-Patterson AFB, Ohio, and at the Aero Medical Field Laboratory, Holloman AFB, N. M., as well as at the School of Aviation Medicine.

These studies are designed to determine the performance of man under a state of reduced gravity to the point of weightlessness and to assess his tolerance to this strange situation. From current data, inference is drawn that man adapts very well to fractional gravity states of short duration.

Tests To Date

The experiments of Dr. S. J. Gerathewohl of the School of Aviation Medicine have shown that about 25% of the subjects became moderately nauseated during maneuvers associated with parabolic flight, 25% were relatively indifferent, and the majority of human subjects enjoyed the experience. These and other studies, extremely important to engineers and bioscientists, must be extended over longer periods of weightlessness before final conclusions can be drawn. Our preliminary observations may have a bearing upon the ultimate selection and training of aircrews for space operations.

This is only a very brief survey of the problems and interests of Space Medicine and its progress. From the fueling of a rocket vehicle through its launching and flight, its re-entry into the atmosphere and ultimate descent, the bioscientists are attempting to identify the problems and obtain solutions.

Toxicity of propellants, forces of acceleration during launching, and deceleration forces upon re-entry are under study in terms of their effects upon the personnel.

The elements of discrimination, decision and judgment still dictate that man is superior to the "black box" in innumerable situations and that he hasn't been ruled out for space flight operations. Our interests always are in the man who flies—from ground level to infinity. ★

Aeroquip

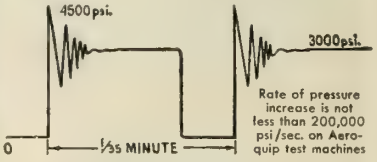
Engineering Notes



B. A. MAIN, JR.

The advertisement at the right reveals a new construction for high pressure hose of Teflon. Naturally there is a reason for going to this type of construction and I'll try to show here why we did it.

The most widely used measuring stick for evaluating high pressure hose is the impulse test. In this test, the hose line is subjected to hydraulic impulse pressure varying from 0 pressure to 3000 psi., with a surge peak pressure which reaches 4500 psi. The pressure curve shape is shown below:



Rate of pressure increase is not less than 200,000 psi/sec. on Aeroquip test machines

A hose line is considered adequate if it will withstand 100,000 cycles or applications of this pressure curve, and in the case of hose of Teflon, the fluid in the hose and the ambient air surrounding it must be held at 400° F.

We began this development by building and testing hoses using conventional two-wire braided reinforcement around the inner tube of Teflon. In the -4 size, two wire braids proved to be adequate reinforcement to withstand the impulse test, each time samples were tested.

In the -6 size, we tested many constructions of two-wire braided hose of Teflon. We explored both 302 and 304 stainless steel wire in sizes from .011" to .015" diameter. We also explored the use of carbon steel wire for the inner braid using various wire sizes. Twelve separate impulse tests involving hundreds of samples were necessary to investigate all combinations; in every case one or more samples failed before completing the 100,000 cycles of impulse. Our experience with the -8 size paralleled that with the -6 size.

The failures always begin with the inner braid. Here, individual wires break at the crossovers which are formed when wires are first brought over and then under other wires in braiding. As soon as a sufficient number of the individual wires break, the hose bursts during the test.

The obvious solution to this problem was to eliminate the crossovers of braiding by substituting the two spiral wire wraps for the inner braid. This required new machinery and techniques, but we now produce the hose successfully.

We have now finished six separate impulse tests successfully on the -6 and -8 sizes. The samples tested have included both carbon steel wire and stainless steel wire for the spiral wraps and both wires passed the 100,000 cycles every time.

Work on this project has convinced me that it is impossible to build a braided hose size -6 and larger which will withstand this impulse test every time the hose might be subjected to the test.

In our tests of the -6 size we did have two successful tests of braided hose, but when these were retested the samples failed, so you can't judge by one test alone.

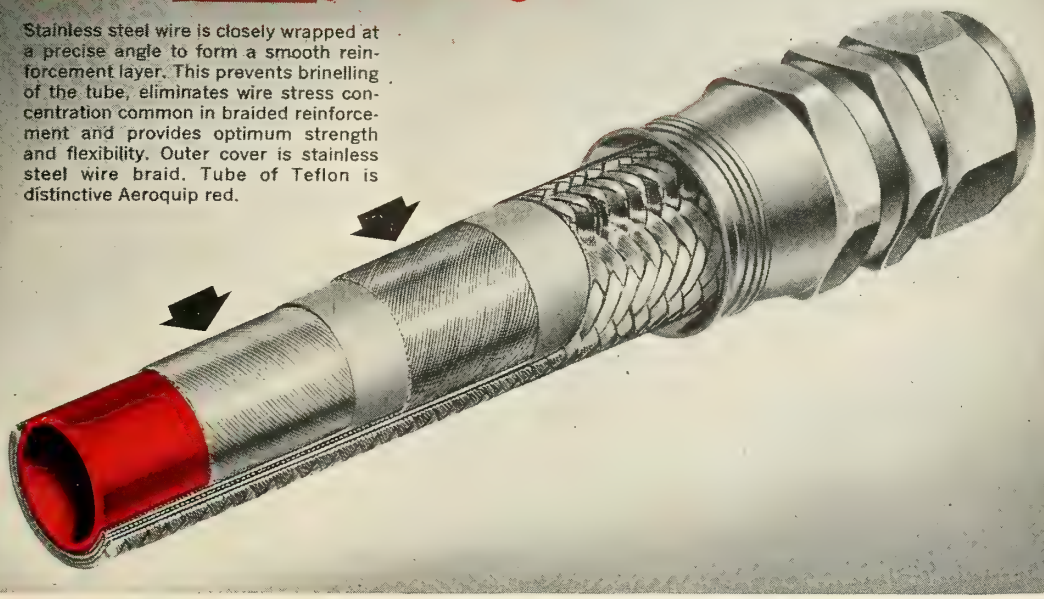
The spiral construction provides the best high pressure hose available today. It can be used at the same bend radii as equivalent two-wire braided hose, and compares nearly exactly in weight and size.

B A Main Jr

VICE PRESIDENT, ENGINEERING
AEROQUIP CORPORATION

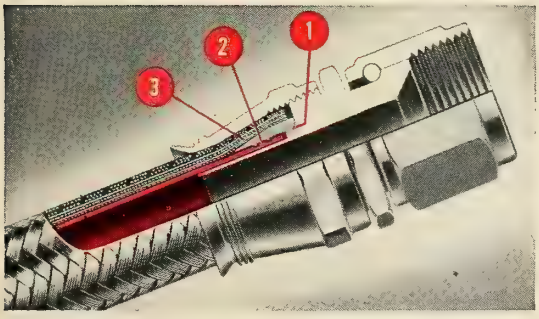
SPIRAL WRAP
adds lasting strength

Stainless steel wire is closely wrapped at a precise angle to form a smooth reinforcement layer. This prevents brinelling of the tube, eliminates wire stress concentration common in braided reinforcement and provides optimum strength and flexibility. Outer cover is stainless steel wire braid. Tube of Teflon is distinctive Aeroquip red.



Specify Aeroquip 677 Hose of TEFLON* and Reusable "*super gem*" Fittings for 3000 psi. Systems

GET ALL THESE IMPORTANT ADVANTAGES:



Leakproof, too! This cutaway view shows how Aeroquip "*super gem*" Fittings protect against leakage at all pressures: **(1)** a metal-to-metal line seal; **(2)** a lip seal formed by the tube of Teflon seated, but not compressed, between the nipple and sleeve. Compression of wire reinforcement **(3)** assures positive grip and lasting protection against fitting blow-off.

*DuPont trade name for its tetrafluoroethylene resin.
"*super gem*" is an Aeroquip Trademark.

Hose Strength that lasts and lasts! The secret is in the hose construction perfected by Aeroquip . . . multiple spiral wrap reinforcement that resists impulse fatigue and prolongs the life of the hose line.

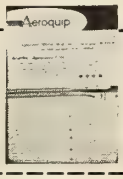
Reusable "super gem" Fittings that cut costs! Fittings are often the most expensive part of a hose line, well worth saving when engineering or production changes call for fluid line alterations. With "*super gem*" Fittings you save ALL, not part, of the fittings. Hose line assembly and disassembly is quick and easy, using ordinary bench tools.

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Aeroquip (Canada) Ltd., Toronto 10, Ontario

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REG. TRADEMARK

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rocketeer profile

Pied Piper Bob Truax

By Erica Cromley

. . . a glimpse behind the braid of the man who spurred the Navy's rocket program

CMDR. ROBERT C. TRUAX is said to be the only man ever to fire a rocket in the engine room of a U.S. naval vessel. Let us hope so. A man who has earned many honors for his "firsts" in Navy rocketry, Bob Truax feels this is one tribute he can do without. He claims innocence.

The Navy's rocket expert does admit, however, that he rigged up a rocket engine test stand aboard the USS *Enterprise* in 1940 and continued the rocket experiments he had begun as a teenage Naval Academy midshipman in the late 1930s. Although the shipboard project was encouraged by the skipper, Navy sources say there was an audible sigh of relief when the young rocket enthusiast was assigned to the Bureau of Aeronautics. Bob Truax, now 39, has lived rockets since his boyhood days when he did his rocket tinkering in the basement. While a midshipman at the Naval Academy he badgered everybody and anybody for bits, parts and pieces from which to make a rocket engine. The U.S. Naval Engineering Experiment Station near Annapolis helped him build a test stand.

He was unable to evoke a single explosion, but six years later in 1945, after he had graduated and was back at the test station, he effected what he describes as a "doozie." It shattered bulletproof glass. The device—a nitromethane engine.

In August 1946, he was ordered to BuAer in charge of rocket powerplant development, having, in effect, sole responsibility for BuAer's progress in this field—a $6-million-a-year project.

Among the projects he mothered were development and test of the powerplants for the D558-2, the *Viking* and the earth satellite vehicle (1946-1948).

Says the rocketeer in recollection, "At this time I completed a study of a long-range [1100-mile] ballistic missile for fleet use and succeeded in getting BuAer endorsement on a program to develop this missile. The program was rejected by the Chief of Naval Operations. This engine is slated for use in the NAA X-15 airplane."

Four years later, with a master's degree in nuclear engineering, he was assigned to head the BuAer surface-launched branch of the guided missile division. Here he supervised the *Rigel, Lark, Regulus* I and II projects.

He says of this stint: "My duties also included proposing new projects. I vigorously advocated initiation of a ballistic missile program and an anti-ASW missile of original concept."

In the fall of 1954, he was borrowed by the Office of Naval Research to study the problem of fleet air defense. His report, submitted six months later, resulted in sweeping changes in the missile radar control equipment and shipbuilding programs. He still has the letter of commendation from the Chief of Naval Research for this work.

Bob Truax, perhaps more than anyone else, was responsible for getting the Navy started on its rocket program. However, the Navy apparently didn't move fast enough for him and it wasn't long before the Air Force requested that he be assigned to its ballistic missile program.

Currently the naval rocket pioneer channels his talents into the Ballistic Missile Division Headquarters, Air Research & Development Command. Title: Deputy Director, USAF Ballistic Missile Division.

Since he joined Maj. Gen. Bernard Schriever's staff, Bob Truax has been working on the Air Force' reconnaissance satellite project, frequently referred to as Project *Big Brother*. The project's name, however, is *Pied Piper*.

This satellite, which was originally part of President Eisenhower's open-skies plan, started out as nothing but a study project. Today the project has come to life, more money has been granted for it, and Bob Truax is expected to be stuck with it for some time to come.

Only a few of the Truax achievements in rocketry are recorded here. He has received awards from various scientific associations for his work, has published many papers and reports of inestimable value to other rocketeers and holds seven patents for aero-rocket devices. He was a director of the American Rocket Society from 1947 to 1950 and is about to step down as its president next month.

In tribute to his work, the Navy has a couple of honors in the works: the Legion of Merit Award "for his continuous outstanding service in the field of rockets and missiles," and a promotion to captain.

Considering his achievements, a portrait would emerge of an intensely

The Truax talents run in many directions. This is the Truax-designed home in Arlington, Va.





Junior and Senior Truax sea-shelling on family weekend trip.



Posing for dad. Ann, 15; Kathleen, 13; Steven, 11; Gary, 6.

dedicated, senior, introverted science type, with no time for anything but his life's work. Not so.

Bob Truax takes his work seriously; himself, not. He has a tremendous zest for living which is immediately apparent on meeting him. He resembles nothing so much as an exuberant undergraduate (crew-cut included) who has just received a bigger check from home than he expected.

The 39-year-old rocket whiz has been termed by his friends as magnetic and dynamic, with boundless energy and countless friends. Said one, "I have never heard him say an unkind thing about anyone." His co-workers all use identical phrases when they describe him: extremely dedicated, gets along well with everybody, farsighted, extremely modest and not aware of his greatness.

He has a flair for expressing himself well which puts him in great demand as a toastmaster. Though modest about his rocket achievements, the Truax pride is vocal where his family is concerned. There are four junior Truaxes ranging in age from six to 15. None of them are basement rocket tinkerers. Six-year-old Gary is more interested in making airplanes, collecting bones and skulls. He also likes to draw spaceships. "Watch today's kids," says father Bob. "What they draw today may well turn out to be the designs of tomorrow."

Steven, 11, who just became a boy scout, gets his kicks on the baseball diamond as a Little Leaguer. Kathleen, 13, is taking art lessons, and 15-year-old Ann, who wants to be a nurse, has her head buried in first-aid books.

Indirectly, rockets were responsible for Rosalind and Bob Truax getting together. In 1938 during a search for a refractory material for a nozzle, he met Carl Schroeder, a metallurgical engineer from New Jersey. At the invitation of mutual friends, Schroeder and Truax met to talk over nozzle problems. The friends also invited Schroeder's daughter, Rosalind. This led to an invitation to the hop at Mem Hall, a three-year courtship and a trip to the altar in July 1941.

They set up housekeeping in Annapolis. Here Bob Truax started on the JATO development project at the Experiment Station a few months before Pearl Harbor. They have moved 22 times in the 16 years since.

The commander describes his current home as a "typical California tract house, what you call a rambler though this one doesn't ramble far." They're renting. Home is in Arlington, Va., a Truax-designed house complete with work-saver cabinets. "A showplace," he says in a rare burst of immodesty.

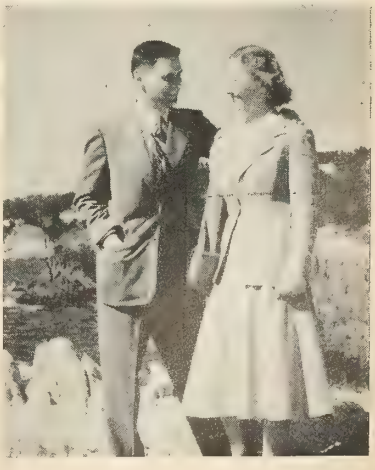
The Truaxes are outdoorsy types. There are family hiking and camping weekend trips. A recent such excursion took the family on a canoe trip down the Colorado River.

He looks forward to spending time with his family but admits it is not nearly as much as he would like. The experiments still go on in the basement where he concocts electronic devices using the "cookbook" method. And like many a cook, chef Truax's concoctions do not always turn out as planned. Once he started out to make a Geiger counter and wound up with a computer. He expects to track *Sputnik* with a six-inch reflecting telescope of his own making.

Bob Truax is a nonsmoker, nondrinker and easy to please in the food department. Preferences run to hash, and macaroni and cheese. This may be more than a matter of choice. In addition to six Truaxes, the Navy rocketeer supports two cats, one black cocker and a horse. Dog is named Jet. Horse is named Rocket. Of course.★

Below—Hometown father and son game in Rolling Hills, Calif., with Father Bob at bat.
Right—The Truaxes at Monterey, Calif. They have moved 22 times in the past 16 years.







MISSILE AGE

By Norman L. Baker

Lockheed Offers Satellite and Moon Rockets

The Missile Systems Division of Lockheed has proposed a practical, realistic approach to the task of gathering upper-atmosphere data desperately needed in our ICBM, anti-ICBM, satellite and missile programs. The beauty of the Lockheed proposal is the use of a family of research rockets evolving from the successful X-17 re-entry test vehicle that will reach altitudes ranging from 200 to 8000 miles up and out. Most advanced models could reach orbiting and escape velocities.

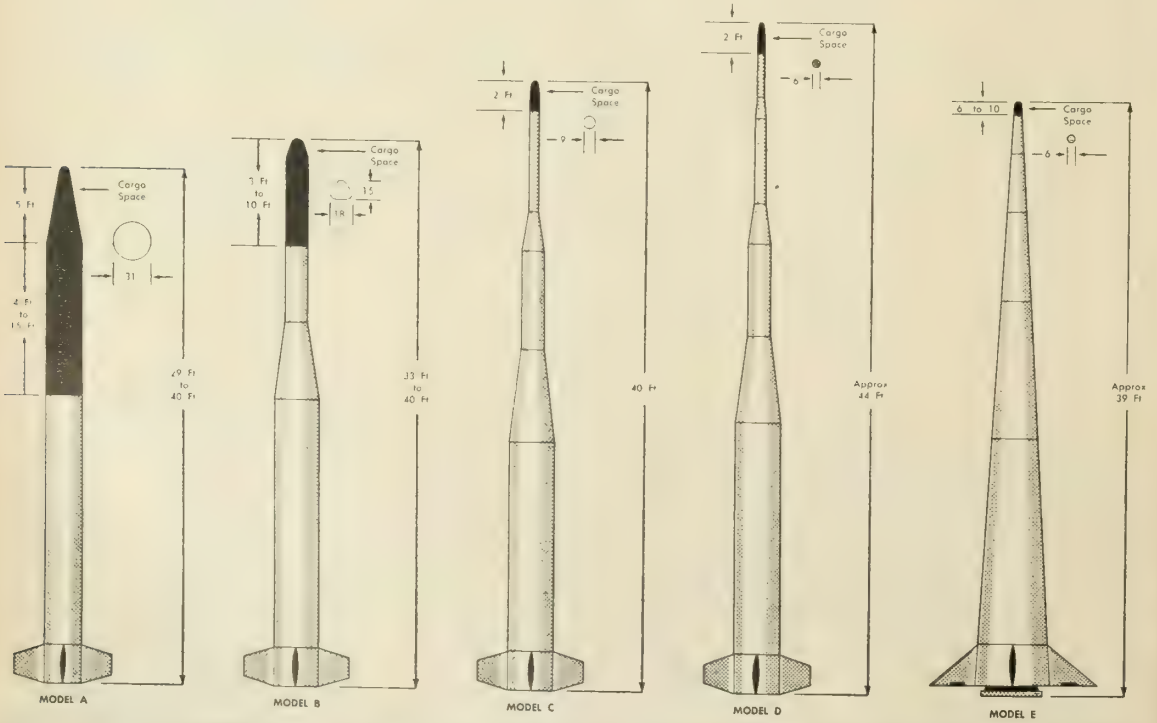
Designated *Explorer,* the series consists of five models ranging from one to five stages. The vehicles combine a wide range of payload and altitude capabilities with reliability, safety, simplicity and easy portability. Rocket motors are "off the shelf" solid propellants, developed by the Thiokol Chemical Corp., that have been thoroughly flight-tested in previous operations. The staged vehicles use a combination of *Sergeant* and *Recruit* rockets. The *Recruit* is the same rocket that is used in the four-stage *Far Side* vehicle.

The performance characteristics of the *Explorer* models make them acceptable for geophysical and communications data gathering. The high g accelerations (100 g) expected with this type of vehicle make them unsatisfactory for the evaluation of components or equipment sensitive to rolling or high g forces. A vehicle incorporating roll stabilization and guidance is now under study and will meet the requirements needed for evaluating highly sensitive components in the ICBM and AICBM programs.

It became obvious during the X-17 program that a vehicle of similar capabilities could be utilized to investigate the problems beyond those of immediate concern to the ICBM re-entry phase. A re-evaluation of the X-17 vehicle resulted in the *Explorer* series. The *Explorer* would embody the same dependability and portability as the X-17, but with a much wider range of capabilities.

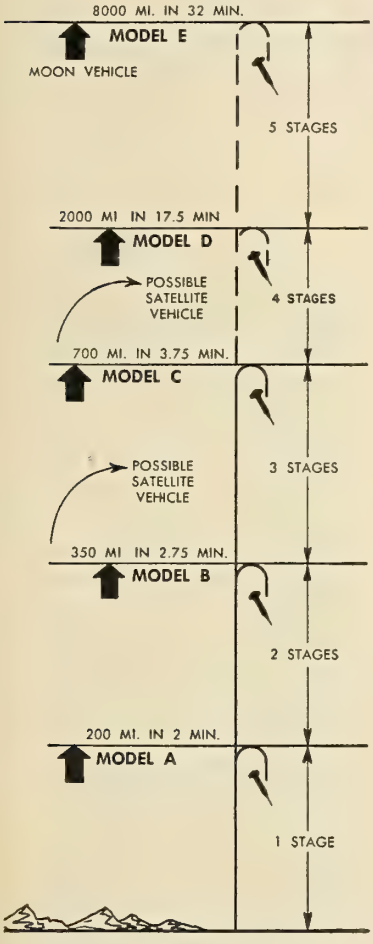
Model A

This is a single-stage vehicle utilizing the Army XM-20 *Sergeant* sur-



MODEL A: XM-20 SERGEANT, gross weight 9000 lbs., thrust 50,000 lbs., MODEL B: gross weight 10,000 lbs., thrust (first stage) 50,000 lbs., (second stage) 104,000 lbs., MODEL C: X-17 research re-entry vehicle, gross weight 10,400 lbs., thrust (first stage) 50,000 lbs., (second stage) 104,000 lbs., (third stage) 34,000 lbs., MODEL D: gross weight 10,459 lbs., thrust (first stage) 50,000 lbs., (second stage) 104,000 lbs., (third stage) 34,000 lbs., (fourth stage) 1680 lbs., MODEL E: gross weight 19,000 lbs., thrust (first stage) 62,000 lbs., (second stage) 115,000 lbs., (third stage) 37,300 lbs., (fourth stage) 8100 lbs., (fifth stage) 1800 lbs.

face-to-surface missile powerplant. The cargo compartment, 31 inches in diameter and four to 15 feet long, could carry from 100 to 500 pounds of instrumentation. Its ability to remain at peak altitude of 200 miles for as long as two minutes makes it suitable for collecting geophysical data. As a testing range instrumentation vehicle, with a payload of 100 pounds, it would have a range of 400 miles and an apogee of 50 miles.



Model B

This two-stage model would use a *Sergeant* first stage and three *Recruit* rockets for the second stage. The aerodynamic design has already been proved in flight. Instrumentation payload could weigh from 80 to 500 pounds. It would be capable of remaining near peak altitude of 350 miles for almost three minutes.

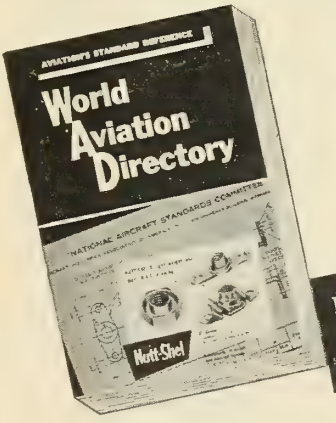
Model C

Identical to the X-17, this three-stage model has a *Sergeant* motor for the first stage, three *Recruits* for sec-

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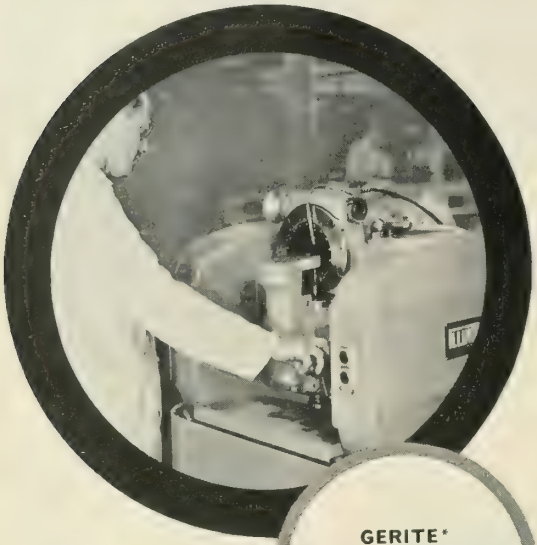
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ond stage and a single *Recruit* for the last stage. With a 50-pound payload it has a peak altitude of 700 miles or 350 miles with a 250-pound payload. The payload space is nine inches in diameter and two feet long.

Model D

This four-stage rocket, and the Model E, would require further development in order to achieve the desired ranges of altitude and payload capabilities. Requiring only a mimimum of development, the Model D could be made by adding a fourth stage rocket, similar to the *Arrow*, to the Model C. It would carry a 10-pound payload to an altitude of 2000 miles. It would place its payload near peak altitude for almost 18 minutes.

Model E

Lockheed states that this version is based on a proven and reliable design concept with capabilities of extending measurements into the region from 2000 to 8000 miles above the surface of the earth. Using currently available solid propellants, it is expected to exceed satellite orbital velocities. Escape velocities are possible with recent propellant improvements. This rocket vehicle could, with adequate guidance, transport a payload to the surface of the moon. Preliminary design results indicate that a cargo space six inches in diameter and six to 10 inches in length will be available for a payload of 10 pounds.

In addition to the basic vehicle, Lockheed could make available all the necessary equipment and organizational capabilities for use with the *Explorer* flights. The equipment includes the launcher, umbilical stand, mobile crane, handling slings, mobile scaffolding, forklift, and tractor and lift-trailer combination for towing and erecting the missile.

The original Lockheed proposal for the *Explorer* research vehicles was made at the beginning of the IGY. It was well received by the National Committee for Rocketry and Meteorology, but due to lack of funds for further programing the *Explorer* project is still in the planning stage.

Lockheed's approach to the missile and space research program is indicative of the realistic thinking of some of the top planners in our research programs. A recent example of this approach was the *Far Side* project.

Few companies holding large defense contracts are willing to become involved in a low cost, small quantity production item like the *Explorer*, especially when the major components of the vehicle are manufactured by another company.

Litton Chamber Probes Space Conditions

An inhabited high-vacuum laboratory has simulated the pressure conditions that prevail 95 miles above the earth.

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The laboratory will be used to facilitate the advancement of knowledge about the behavior of physical phenomena, equipment and instrumentation under conditions of extremely low pressure and density.

Also to be explored by the new laboratory is the chamber's applicability to electron-tube research.

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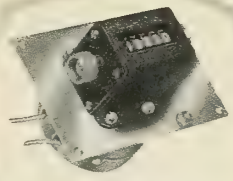
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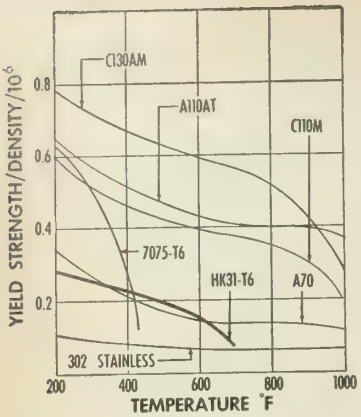


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Grand Central Builds Rocket Fire Fighter

The U.S. Forestry Equipment and Development Center at Arcadia, Calif., is evaluating the *Little Vanguard* solid-rocket-propelled forest fire extinguisher. Developed for Grand Central's own protection on its 8000-acre



mountain-walled test site, it first attracted national attention when a mass firing was demonstrated publicly.

It is a solid-propellant-powered missile slightly over 54 inches in length and is launched from a simple wooden trough. Payload is 8.5 gallons of borate or 76 pounds of other material. On impact it covers a splatter area of 700 square feet. Range is 410 yards with one rocket motor or 1200 yards with two motors.

Aeronutronic Plans for Advanced Missiles

Aeronutronic Systems, Inc., Ford Motor Co.'s West Coast subsidiary, has leased 100 acres and optioned a like amount as a site for its new multi-million-dollar research and development center near Newport Beach in Southern California.

Construction will begin immediately on the first unit, a series of aerothermochemical laboratories to explore problems associated with the design of advanced missile systems. These include anti-missile systems, reconnaissance systems and upper atmosphere vehicles. April 1958 is the targeted completion date for the first phase.

Propeller Company Turns to Rockets

For many years a byword in the propeller manufacturing field, Hamilton Standard is offsetting the problems of reduced defense appropriations and declining volume of business by greatly expanding their missile efforts.

Hamilton's latest expansion, a 410,000-square-foot building, will move them still more firmly into the jet propulsion era. It is probably the largest facility built solely for the development, testing and production of controls for turbine, atomic and rocket engines.

Hamilton Standard currently is producing air conditioning systems, turbine starters, hydraulic pumps and pneumatic valves as well as fuel controls, and is developing still newer products for the turbine and missile fields.

American Rocket Co. Plans Lithium Production

American Rocket Co. announces that it has been working on lithium rocket propellants for about a year. The high-energy propellants are based on lithium perchlorate, nitrate and other chemicals. Both solid and liquid propellants have been formulated and are being evaluated.

Aerojet-General Awarded $55-Million *Titan* Contract

Aerojet-General was recently awarded a $55-million AF contract for *Titan* engine units. Fabrication and testing of the engines has been under way for several weeks at Aerojet's Sacramento plant.

Manufacture of the large engine components at AF Plant 70 is proceeding on schedule. *Titan* is a two-stage ICBM under development by The Martin Co. of Denver. First-stage engine thrust has been reported at 300,000 lbs., with second-stage thrust at 60,000 lbs. First flights of the *Titan* are expected shortly before January 1st.

Goodrich Increases Rocket Research Facilities

B. F. Goodrich Aviation Products has purchased land and buildings at Rialto, Calif., for expansion of their rocket research program. Goodrich, engaged in rocket propellant research since 1953, will continue research and development in this field in the Rialto location.

Vitro Labs Awarded *Terrier* Systems Contract

Vitro Laboratories, a division of Vitro Corp. of America, has been awarded a contract with the Bureau of Ordnance for systems engineering of *Terrier* guided-missile installations on new carriers of the *Forrestal* class.

The work covers installations on new attack carriers and a nuclear-propelled carrier which has been authorized for construction.



IS YOUR JET ENGINE RPM MEASUREMENT ACCURATE AND SAFE?

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READS JET ENGINE SPEED to GUARANTEED ACCURACY of 10 RPM in 10,000 RPM (±0.1%)

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The new B & H TAKCAL incorporates a refinement of the frequency meter principle. It operates in the low (0 to 1000 cps) range, reading the frequency of the tachometer generator on a scale calibrated in percent RPM corresponding to the engine's RPM. It reads engine speed while the engine is running with a guaranteed accuracy of ±0.1% in the range of 0 to 110% RPM. Additionally, the TAKCAL circuit can be used to trouble-shoot and isolate errors in the aircraft tachometer system, with the circuit and tachometer paralleled to obtain simultaneous reading.

The TAKCAL's component parts are identical with those used in the J-Model JETCAL Analyzer. They are here assembled as a separate unit tester and for use with all earlier models of the JETCAL Tester.

The TAKCAL operates accurately in all ambient temperatures from −40°F. to 140°F. Low in cost for an instrument of such extreme accuracy, it is adaptable to application in many other fields.

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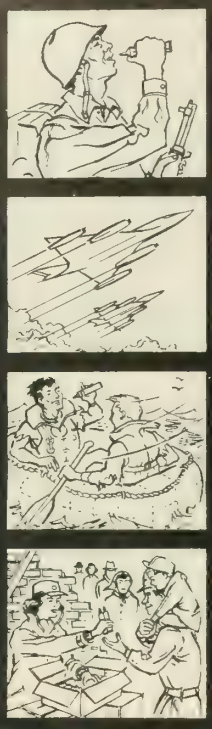
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• The Multi-Meal-Tube contains, ready-to-eat, the equivalent of one complete meal of 720 calories. It provides all the essential food elements required for the maintenance of normal body functions in combination with bulk substances to give roughage residue required for normal gastro-intestinal function. "MMT" requires no refrigeration or special storage.
• "MMT" is less than half the weight and volume of equivalent regular foods.



For further information write the
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Circle No. 75 on Subscriber Service Card.

West Coast Industry



By Fred S. Hunter

Have you heard of "Frescanar?" This is nomenclature for a frequency scanning radar technique Hughes Aircraft Co. has had under wraps since it was first conceived in 1948. First application is in the Hughes-developed AN/SPS-26 shipborne radar system recently installed by the Navy in a guided missile cruiser for sea tests and shipboard evaluation. Reports indicate that AN/SPS-26—an integrated electronic system for accumulating three-dimensional data on all airborne targets—has revolutionary capabilities. Tests on the first model of the surface pulse search system before delivery to the Navy are said to have been highly pleasing to the Hughes ground systems division which developed the antennas and circuits for the Frescanar technique. These tests included many hours of on-the-air operation at high power. The radar system also incorporates some new tube developments, notably a traveling wave tube designed by the Hughes microwave laboratory.

•

Aerojet-General will be back on schedule on solid-rocket production December 1 at Sacramento, where $500,000 worth of fire damage was incurred in two explosions about a week apart. Included in the repair is redesign of the No. 3 line to incorporate production improvements. Aerojet also has a brand new No. 5 line of the latest type going in at the Sacramento solid plant plus a new propellant chemical laboratory. When you mention a line at a plant like Aerojet's, incidentally, you aren't referring to a production line in the ordinary sense. You mean a group of five, six or seven buildings spaced apart and protected by revetments between one another.

•

Boeing now has its YIM-99 logistic depot in operation at Seattle for storage and distribution of spares for the service-test (Y) *Bomarc* interceptor missile, together with maintenance, repair, modification and supply of components. It will serve, in effect, as a "prototype" depot as the Air Force prepares to fit the *Bomarc* weapon into the continental defense. The first *Bomarcs* are scheduled to become operational within the next fiscal year, beginning July 1, 1958. Initial launching of the *Bomarc* prototype took place just five years ago this fall. A ramjet, the *Bomarc's* mission is to intercept fast bombers, but in Seattle recently Lt. Gen. C. S. Irvine, deputy chief of staff, materiel, said the Air Force might look at an advanced version for an anti-missile missile.

•

To keep pressurizing gas from mixing with liquid oxygen used as an oxidizer in liquid-propellant rocket engines, Rocketdyne has come up with a perforated inlet tube to slow down the nitrogen as it is diffused into the LOX system. Instead of mixing with the LOX, the nitrogen is forced to the top of the LOX tank before starting its pressurizing cycle. From 10 to 20 times less dilution of the LOX takes place with the new inlet tube, and this may increase performance up to 30 per cent for a long-range missile.

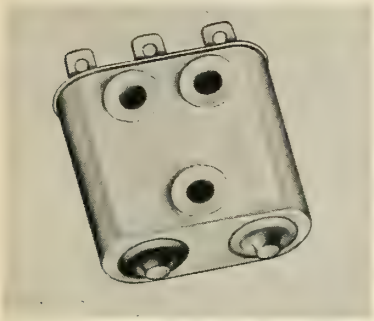
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Lockheed picked Starline Way as the name for a street to be cut through the Sunnyvale missile plant site because it suggests the company's long line of star-named aircraft, now followed by the *Polaris* missile . . . Transistor business now about $30 million a year, is expected to reach $150 million a year in the next couple of years.

NEW MISSILE PRODUCTS

PRECISION SWITCH

Haydon Switch, Inc. has developed a unique type of miniature precision switch which is hermetically sealed, yet unaffected by high ambient pressures. The company claims that the actuation force remains constant even under atmospheric pressures as high as 180 psi. The switch is said to work equally well in a vacuum.



The design is applicable to miniature and subminiature switches of various electrical ratings. The company can also furnish the switch with a seal impervious to the deteriorating effects of immersion in corrosive liquids.

Circle No. 203 on Subscriber Service Card.

MICROSYN

Lear, Inc., is manufacturing a self-contained microsyn of approximately 1" diameter and 1" length, with a sensitivity of 500 millivolts per degree and with a threshold of 0.01 degree at 20V excitation. Linearity is within 0.5% to seven degrees. The subminiature microsyn weighs less than 1.2 oz.

Intended for use wherever there is need for accurate translation of angular displacement into electrical signals, the miniature units may be used in such



applications as position-indication of gyros, control follow-up devices, computation, motion and torque amplification, etc.

The company produces the microsyns with pigtail connectors or with color-coded teflon-insulated terminals. Excitation may be 20V, 400 cps or 25V 800 cos. The units use standard BuOrd mounting and have demonstrated resistance to the most severe environmental conditions.

Circle No. 214 on Subscriber Service Card.

ALUMINUM CASTINGS

New investment casting techniques in aluminum developed by Arwood Precision Casting Corp. are claimed to give higher guarantees of strength and ductility than have ever been possible in aluminum investment castings.

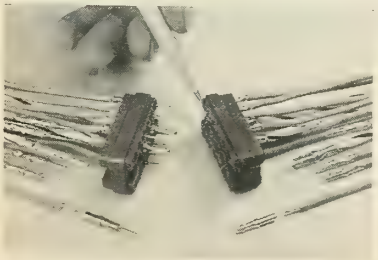
Castings produced by the "suparcast" method can be used wherever aircraft-quality castings are called for, and the user receives minimum guarantees of tensile strength, yield strength and elongation.

In high-stress areas of the casting, Arwood guarantees minimum tensile strength of 38,000 psi, minimum yield strength of 27,000 psi and elongation of 5%.

Circle No. 209 on Subscriber Service Card.

SOLDERLESS CONNECTOR

Solderless multi-lead plug-and-receptacle connectors designed to speed the wiring of electronic harnesses and achieve



greater dependability and versatility have been introduced by Burndy Corp.

Called the "Hyfen" the connector has two mating units, a plug and a receptacle. Instead of being soldered, pins and sockets are crimped to wire ends by single-stroke manual or high-speed automatic tools.

This method is said to be not only faster than soldering but also to make more reliable, more easily checked connections. Elimination of solder fluxes and dissimilar metals improves resistance to corrosion. A minimum number of contact points also reduces reliability problems.

Circle No. 202 on Subscriber Service Card.

SILICONE RUBBER

A new room-temperature vulcanizing silicone rubber has been introduced by Dow Corning Corp. Identified as Silastic RTV 501, it is intended for encapsulating electric and electronic parts and for general potting, sealing and caulking applications.

The material has a long shelf life in the unvulcanized state, is easy to handle and blend and retains its rubber-like properties over a temperature span of from –70 to as high as 500°F.

Silastic RTV 501 may be mechanically or manually mixed as long as three hours before application, in the proportion of 25 parts to one part Silastic Catalyst A by weight. Both ingredients have a viscosity of about 60,000 centistokes, or the consistency of a heavy fluid.

Vulcanization takes place within 24 hours at room temperature. The compound is completely stabilized after 48 to 72 hours. Moderate heating (up to 200°F) will accelerate curing in most cases.

Circle No. 204 on Subscriber Service Card.

ALL-PLASTIC GATE VALVE

The Vanton Pump & Equipment Corp. is making an all-plastic gate valve specifically designed to meet the problems of conveying corrosive and abrasive liquids in lines that cannot be chemically contaminated.

The product, called the "Flex-Plug" gate valve, combines both the straight-through flow, non-pressure drop characteristic of a gate valve and the throttling, flow-control feature of a globe valve, allowing for wide versatility of application. The valve is available in 1" and 2" sizes with screwed ends.

One of the design features of the valve is the resilient synthetic cap which can be removed quickly and replaced easily without removing from the line.

Wear of the resilient cap is at a minimum since the cap is flexible and seated on a swivel that is free to turn. It never reseats at the same place. In addition, because of the flexibility of the cap, the valve can handle slurries despite their abrasive action.

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VARIABLE FREQUENCY MOTOR GENERATOR SETS

ADJUST 360 to 440 CPS.

Generator mounted controls include reset buttons, limit switch. Motor and generator remain stationary. Vari-drive pulley adjustment controlled by small motor. Remote control panels available.



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IMPORTANT DEVELOPMENTS AT JPL



Teamwork in Missile Development

The Jet Propulsion Laboratory provides a wide range of research and development activities. Projects include problems in the fields of Electronic, Mechanical, Aeronautical, Chemical and Metallurgical Engineering, Physics and Mathematics.

The fluid character of these activities provides a keen incentive to JPL engineers and scientists. These men are given wide latitude and unusual individual responsibility—at the same time working as a thoroughly integrated team on all aspects of entire missile systems rather than on certain highly specialized missile components.

JOB OPPORTUNITIES NOW IN THESE FIELDS . . .

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The new Vanton Flex-Plug gate valve has a back-seating feature created by the pressure exerted by the seating of the flexible cap on the bottom face of the bonnet when the valve is fully open, thus relieving pressure of the packing.

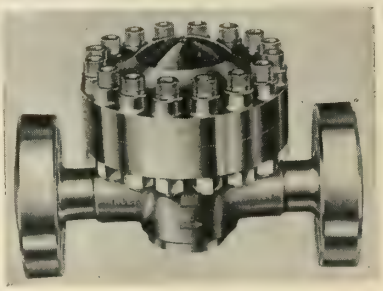
The Flex-Plug gate valve is rated for 200 lbs. working pressure. The valve performs excellently under vacuum service. Research and field tests conducted by Vanton show that seating with a resilient surface against rigid plastic materials will hold a vacuum more efficiently than a metal-to-metal seal.

Circle No. 208 on Subscriber Service Card.

PRESSURE REGULATOR

A servo-dome pressure regulator has been introduced by Accessory Products Corp. which features exceptional accuracy in flow and/or pressure control.

Performance features include identical line and orifice sizes from ¼" to 3"; inlet pressures from 0 to 6000 psi; outlet



pressures from 0 to 5500 psi; zero leakage through positive shut-off; precision control accuracy and instantaneous response; and direct action which eliminates pilot control.

The valve handles a wide range of fluid media—air, gasses and liquids; a temperature range of –65°F to 250°F; internal or downstream sensing control; external or self-contained dome loading; burst pressure is four times rated pressure. Available in stainless steel, aluminum, alloy steel and bronze.

Circle No. 201 on Subscriber Service Card.

FLOWMETER

A new line of lightweight, turbine-type flowmeters with an accuracy of ½% has been developed by the commercial research division of the George L. Nankervis Co. The new flowmeters handle chemicals and other liquids over a wide range of temperature and pressure conditions.

Pressures up to 5000 psi are easily accommodated at temperatures ranging from –80° to 1000°F, viscosity permitting. Designated as the Cox Type 20, the new instruments are available in stainless steel or aluminum.

Accuracy of the new flowmeters is guaranteed to be ±½% of any reading over the 10:1 range of the instrument. Repeatability is ±.1 of 1%.

The flowmeter consists of a stainless steel (or aluminum) housing, a precision turbine wheel suspended in the housing, two flow straightening assemblies and a magnetic pickup coil. It can be calibrated either in gallons per minute or pounds per hour.

A significant feature of the new instruments is the fact that they can be easily disassembled for cleaning and servicing and reassembled without affecting



The Bell XH-40 turbine-powered 'copter . . . the Army's frontline workhorse of tomorrow

DISTINGUISHED PERFORMANCE . . . PLUS ECONOMY!

In designing rotor blades for the XH-40, the Army's most advanced utility helicopter, Bell Helicopter engineers were seeking a structural design that would combine outstanding performance with bedrock fabrication economy.

The solution? A uniquely different kind of rotor blade laminated of multiple layers of thin-gage, contoured aluminum sheets, bonded into an homogeneous structure with a high performance, high peel strength structural adhesive. This structure offers a host of performance and fabrication advantages . . . outstanding aerodynamic smoothness, low maintenance, excellent sealing qualities, high corrosion resistance, plus complete absence of assembly distortion. Furthermore, by completely eliminating stress concentrations, the bonded structure takes full advantage of the optimum fatigue life of the blade configuration.

Best of all, the bonded blade design has resulted in a dollar savings of 40 percent as compared with a conventional tapered forging design.

The adhesive used to accomplish the unusually large area bonding required in the fabrication of these laminated blades? A Narmco product, naturally . . . high peel strength, high fatigue resistant Metlbond 4021®. . . one of a great family of sandwich and metal-to-metal adhesives designed specifically to accomplish the toughest jobs in aircraft and missile design.



Cutaway cross-section of inboard half of the XH-40 rotor blade showing how the extrusions, machined parts, and contoured aluminum sheets are bonded with Narmco Metlbond 4021.

NEW FROM NARMCO

Narmtape® 108

the first structural sandwich adhesive with built-in filleting action! Complete technical data available upon request.

Write today for specific performance and fabrication data on NARMCO structural adhesives. Narmco technical field representatives throughout the United States and Canada can assist in solving your structural design problems quickly, efficiently, economically.

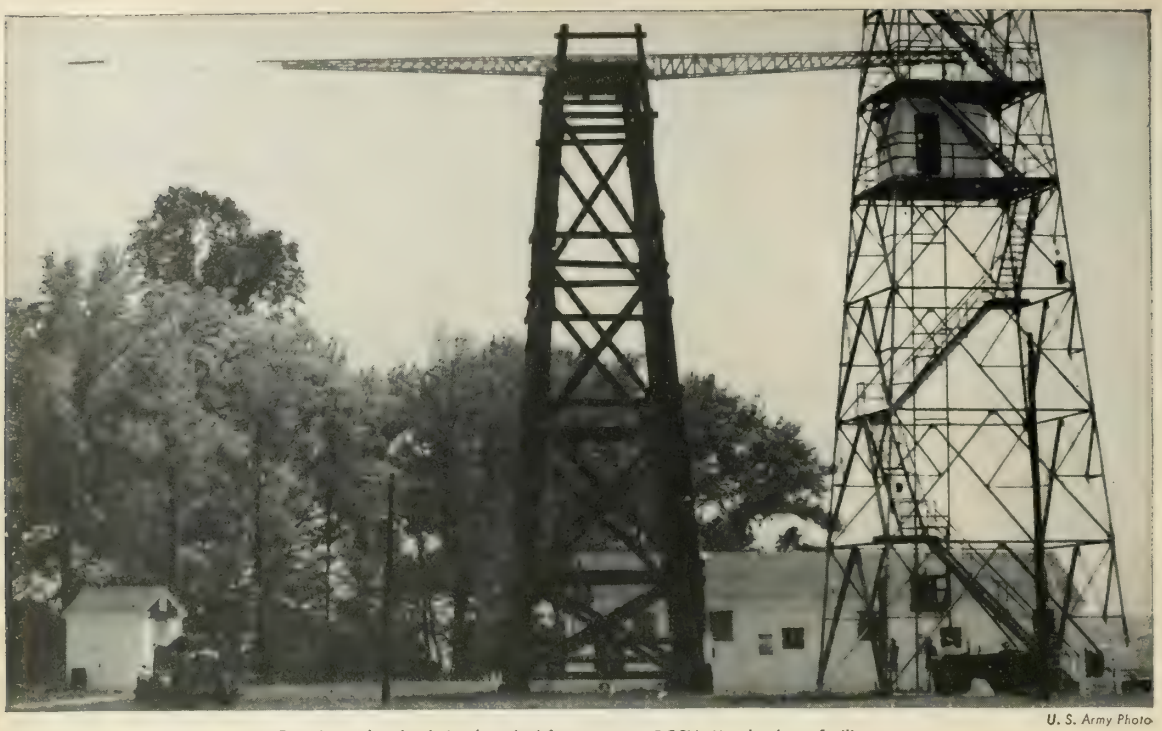
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U. S. Army Photo

Experimental rocket being launched from tower at DOFL's Maryland test facility.

ELECTRONIC AMMUNITION THAT "THINKS" IS DEVELOPED AT ARMY'S DIAMOND ORDNANCE FUZE LABORATORIES

Since 1940, scientists and engineers at Diamond Ordnance Fuze Laboratories, with their industrial contractor counterparts, have made important contributions to electronic ordnance. These include the proximity fuze, greatly improved fuzes for antitank and other special ammunition, and, more recently, fuzing systems for guided missiles. Other basic results of DOFL's research and development teams are new electronic systems which increase the accuracy of measurement of distance, velocity and direction, new electronic and mechanical control systems, and new and radical components and materials. DOFL's main laboratory is in Washington, D. C., and it maintains an extensive test facility at Blossom Point, Maryland. Over 1400 scientists, engineers, technicians, and supporting personnel work in these centers.

Electronic ordnance was born in World War II. Ammunition of this type, a DOFL specialty, senses the presence, distance, and direction of a target and causes the warhead to function at the instant when it will inflict the most damage. Electronic control can be compared to having a sharpshooter in every piece of ammunition. The accurate effect is devastating.

Many advances in ruggedness and miniaturization, pioneered by DOFL, are contributing significantly to peacetime technology. Typical industrial products which sprang from ordnance programs are printed electronic circuits, tough and tiny electronic tubes, and rigid mounting of components in solid plastic blocks. These valuable by-products have contributed heavily to the ability of DOFL's industrial teammates to design safer, smaller, and better components.

This is one of a series of ads on the technical activities of the Department of Defense.

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linearity. Twelve sizes of flowmeters, with capacities ranging from .25 to 125 gallons per minute, are available.

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FREQUENCY CONVERTER

Designed for application with guidance systems and in telemetering functions, a new transistorized frequency converter is being marketed by the Aeronautical Division of Robertshaw-Fulton Controls Co.

A substantial size-weight reduction is said to have been achieved over previously available rotary electro-mechanical frequency converters. Use of transistorized circuitry has reduced weight and overall size by approximately 60 per cent, and brought about minimum maintenance conditions.

Circle No. 215 on Subscriber Service Card.

HYDRAULIC PUMP

A large capacity variable delivery hydraulic pump has been developed by the Stratopower Division of The New York Air Brake Co. The pump, designated as the STRATOPOWER 64W1000, is claimed to have several design advantages over existing pumps on the market, including high horsepower per lb. ratio (2.8 hp/lb.), a light, compact package delivering over 50 hydraulic horsepower in an envelope 9⅛ x 6¼ inches weighing approximately 19 pounds, and exceptional control stability.

Other features include high overall efficiency of 90 per cent or more, low inlet pressurization of under 50 psi at full speed, self-aligning rotating members and exceptionally low pulsation and oversurge characteristics.

Circle No. 205 on Subscriber Service Card.

MAGNETIC HEAD

A 7-channel magnetic tape recording head developed by Data Storage Devices Co. can be directly connected to thermocouples to record without the use of amplifiers, using only 20 microwatts. The complete system is carried aboard a missile and the head has been designed to withstand high shock and vibration forces as well as high temperature and thermal shock.

Other features of the small, lightweight, aluminum head include gap alignment scatter under 1/10 MIL, mounting base machined to within 90° ±15 seconds of the gap line and tape guides integral with the head.

Circle No. 216 on Subscriber Service Card.

TAPERED ORIFICE VALVE

A valve expected to replace needle valves in nearly all applications has been introduced by General-American Valve Co. The tapered orifice valve features a new concept of flow control and will pass foreign particles up to twenty times larger than comparable needle valves.

By moving a plug with a tapered slot into an out of the circular valve opening, the flow of fluid or gas is controlled by the area of the tapered slot at the head of the opening. A circular sealing ring eliminates by-pass.

Principal advantages of the new type valve are its high accuracy in flow control, infinitely variable control, non-clog-

LIQUID OXYGEN AND NITROGEN TRANSPORT UNITS



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Built to A.S.M.E. and I.C.C. specifications in sizes from 500 to 3500 gallons. Efficient performance is shown in this Hofman powder in vacuum insulated equipment. Standard features include: bottom fill and discharge line, top fill line, liquid level gauge, vacuum valve and filter, thermocouple vacuum gauge, pressure gauge, A.S.M.E. code stamped inner vessels, quick pressure build-up system, extended stem valves on liquid lines, ending with Hofman quick couplings.



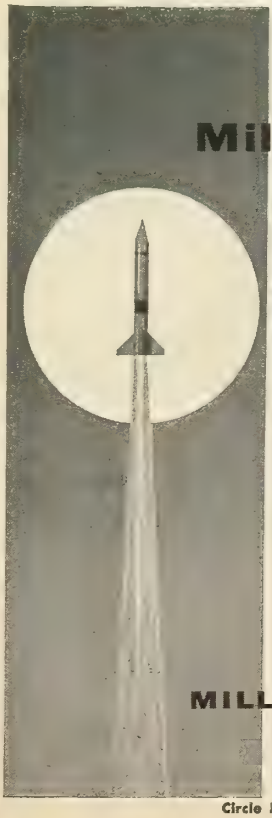
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CHIEF OF DESIGN

This internationally known aeronautical equipment engineering and manufacturing firm is looking for a "balanced", premium quality Chief of Design. The salary, very high, matches the requirements.

Must have proven creative design ability. Must be able to lead, and inspire, two groups . . . more than 100 engineers and more than 150 detail and layout draftsmen. Offer constructive criticism and evaluate their efforts. An able assistant will relieve him of routine duties.

Naturally, he must have a broad knowledge of manufacturing techniques for a variety of mechanical and hydraulic devices. He must understand cost factors, both from a development viewpoint and in-operation amortization viewpoint. He must keep current on not only all skills and techniques employed by his company, but throughout the industry.

In summary: our Chief of Design will constantly judge designs and drawings for functionalism, sound integration into existing components, and legitimacy of production from a profit perspective. He must maintain and guide technical groups to achieve such output economically.

Reply to: Mr. Robert F. Webb, 250 Park Square Building, Boston 16, Massachusetts

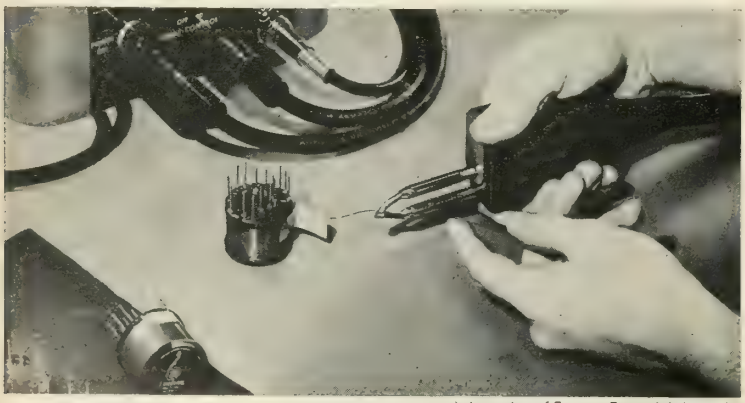


photo courtesy of Emerson Research Laboratories

WELDMATIC PRECISION WELDING IMPROVES COMPONENT RELIABILITY FOR EMERSON

Joining lead wires to magnetic amplifiers was a problem at Emerson Research Laboratories. However, using a Weldmatic Model 1012 welder, they found they could join materials like #40 nickel iron resistance wire and #24 tinned copper both quickly and easily. Resulting joints proved *reliable*—able to withstand severe vibration, acceleration and high temperature. With Weldmatic welders you can simplify miniaturization, speed production. Write for technical data on the Weldmatic line.

WELDMATIC DIVISION OF UNITEK CORPORATION
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SALES ENGINEERING REPRESENTATIVES IN PRINCIPAL CITIES
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ging, non-freezing, abrasion-resistance and an excellent coefficient of flow at all settings with very low turbulence.

The company says the valve has been thoroughly field tested and is available in many sizes, pressure ranges and connections.

Circle No. 207 on Subscriber Service Card.

LIQUID SPRINGS

A miniature spring using liquid compressibility has been developed by Taylor Devices Inc.

The ½" diameter, self-contained liquid spring developes 800 lbs. force at ¼" stroke with an 80 lb. preload and is only 2" long plus ⅜" mounting stud. By the use of an internal hydraulic levering principle, the liquid spring produces up to 20 times the force of a standard coil spring of the same diameter and length. Liquid springs and Spring Shoks up to 50,000 lbs. force are available from the company.

Taylor's liquid springs, with standard ⅜-24 mounting thread, are preloaded and completely self-contained, eliminating stripper bolts, washers and mechanical springs.

Circle No. 200 on Subscriber Service Card.

PRINTED CIRCUIT CONNECTOR

A printed circuit connector with patented polarizing screwlocks has been developed by the electronic sales division of DeJur-Amsco Corp. The right-angle construction precision connectors are designed for printed board or printed cable applications, and withstand vibration and high altitude. Contact spacing is based on .100 grid and the connectors are available in 11 or 33 contacts.

Circle No. 210 on Subscriber Service Card.

STRETCH FORMING MACHINE

A two-way stretch forming machine for use in forming integrally stiffened missile skins is being introduced by The Hufford Corp. Described as a bi-axial stretch-forming machine, the unit handles wider and heavier sheets in which the stiffening ribs have been extruded, and holds tolerances not possible on other types of forming equipment.

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Reeves-Hoffman crystal-controlled oscillators, available over a frequency range of 4 kc to 250 kc, are transistorized for compactness. Length (seated) is 5½"; diameter 1⅜". The oscillators are capable of surviving shock of 100 g's and withstanding vibration of from 5 to 55 cycles at 0.030-in. total excursion. Output power is 600 microwatts. Frequency stability is ±0.015 per cent over an ambient temperature range from −40°C to +60°C. Over the same range of operating temperature, out-put level stability is ±2 decibels from the 25°C level. The oscillators are mounted in a plug-in octal base.

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Address all inquiries to:
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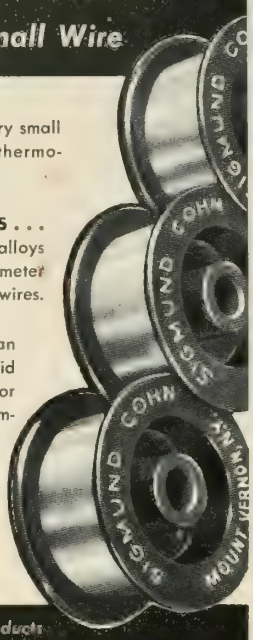
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K-FACTOR TESTER

Specific thermal conductivity of materials is measured with a K-factor tester developed by Tatnall Measuring Systems Co. The device consists of a portable hot plate unit, a cold bath and a relay rack. The hot plate unit is a seven-layer sandwich of plates held together by spring-loaded bolts. The unit and electrical connections are enclosed in a bag of thin plastic. The two outside plates are metal coolant plates and the three central members form the heating part of the apparatus. Specimens up to 1.25" thick are held between the coolant plates and the heating section. Special models operating at temperatures up to 600°F are available. The cold bath comes in three models which operate from room temperature down to —100°F. Various models use water, water and glycol, or alcohol and solid CO_2 for coolant, depending on the operating temperature required. Measurements take from two to six hours, depending on specimens, and readings may be taken from the recorder on the relay rack or from a potentiometer.

Circle No. 208 on Subscriber Service Card.

ROCKET IGNITER TESTER

Model 101-5A igniter circuit tester has been approved by the Army Field Services Division and the Safety Engineer at the Office of Chief of Ordnance. Featuring very low output for maximum safety, the 101-5A is used for preflight testing or for routine quality control igniter inspection.

Unit has .005 amp. output and this is achieved at net loss in accuracy which is —.01 ohm in the 0 to 5 ohm range, and —.02 ohm in the 5 to 30 ohm range. Instrument is suited for field use because of its portability, fast operation, weatherproof construction, one-year battery life, and 4-place digital readout.

The tester is manufactured by Allegany Instrument Co., Inc.

Circle No. 258 on Subscriber Service Card.

CO-POLYMER SEALING COMPOUND

Stillman Rubber Co. has developed a compound said to have exceptional oil and fuel resistance at extreme temperatures for use in bonding and sealing operations. Designated SR 251-70, the compound is available for prototype and small production orders.

The compound may be bonded to aluminum and many other metals, making it suitable for poppet applications at temperatures as low as —65°F. For dynamic sealing, minimum recommended temperatures range from 400° to 500°F, depending on duration of heating. The material is suitable for both dynamic and static sealing.

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CHECK VALVE

High pressure valve operating at 5000 psi (7500 psi proof, 12,500 burst) and from —320°F to 450°F in fuming nitric acid, LOX, liquid nitrogen, propylnitrate, anhydrous ammonia, helium, hydraulic fluids and other liquids and gases. Construction is of Carpenter #20 steel with body poppet and stops, Hayne's alloy #25 steel spring, entrapped Teflon seat; available from ¼" to 1". Cracking pressure is ¼ psi and a variety of port sizes are available.

Circle No. 217 on Subscriber Service Card.

LIQUID DENSITY MEASUREMENT

Precision Thermometer and Instrument Co. has developed a precision device for measuring liquid density of continuously flowing process liquid. The device has zero-set and temperature adjustments for original calibration under working conditions and to provide temperature-corrected specific gravity readings. Readings can be made directly without reference to charts or graphs. The instrument is for use at temperatures to 220°C, and is available in ranges from .01 to .50 specific gravity. It can be used at pressures up to 125 psi., and is equipped with standard connections.

Circle No. 221 on Subscriber Service Card.

PRECISION AIR GAGE

Precision air gages to check gimbal alignment and concentricity are being produced by Federal Products Corp. The three readings, gimbal alignment with each pivot with the centerline of the gimbal and concentricity of one pivot with the other, are indicated simultaneously on dials of a triple-unit air gage. Dials are graduated to 20 millionths of an inch.

The company says that gages have been developed to handle gimbals up to two feet or more in diameter, and the techniques can also be applied to the accurate positioning of parts when machining to tight tolerances.

Circle No. 222 on Subscriber Service Card.

RADOME CERAMICS

Kearfott Co. has announced the availability of high-purity, aluminum oxide ceramics for use in radome construction. The material is said to have unique dielectric properties in the microwave region. At 50kMc its loss factor is only 0.000093; X-band and Ku-band loss factors vary from 0.0017 at room temperature to 0.00017 at 1000°F. Most significantly, its dielectric constant of 9.38 ± 1% remains stable over the entire temperature range up to 1000°F. The material has a frequency loss at high temperatures 50 times smaller, and at 10kMc the loss is 20 times smaller, than commercial high alumina materials.

Circle No. 223 on Subscriber Service Card.

BALANCED MIXER

A series of millimeter wave balanced mixers (Series MA-1026) has been developed by Microwave Associates, Inc. The series is designed for use with RG-96/U waveguide transmission systems and when used with matched pairs of 1N53 or 1N53A coaxial mixer crystals, the units provide high local oscillator noise suppression in Ka-band radar receivers over the 34-36 KMC/s range. The VSWR is 1.3 maximum, balance is ½ db, cross talk is 20 db minimum, and output capacity is 3 uuf, nominal.

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PRESSURE REGULATOR

A hand-adjustable pressure regulator and relief valve for accurately controlling gases such as helium, nitrogen and compressed air, under pressures up to 3000 psi has been developed by Futurecraft Corp. The regulator, termed the Hi/Lo handloader, is of the zero-bleed internal venting type with hand-adjustments of the control knob regulating pressure and providing pressure-relief over the entire 0-3000 psi range.

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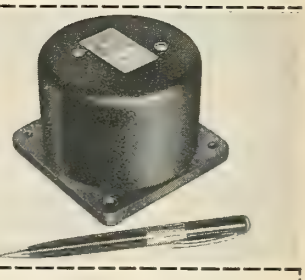
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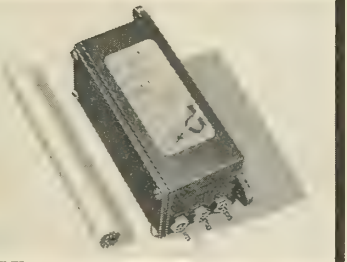
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missile miscellany

It's spelled S-P-U-T-N-I-K; pronounced SPOOTNIK; means "fellow traveler." It also means that we, as a nation, have goofed badly. We insisted Vanguard had no military or political significance—wrong on both counts. We separated Project Vanguard from all other (military) projects—and isolated it from all other knowhow and proposals. We stubbornly refused to consider at least two other vehicles which could have placed a satellite (of much political and some scientific significance) in an orbit—the X-17, 18 months ago; Jupiter-C, at least a year ago. Either could have and still can get an 18-to-20-pound beeper up there. Army not only has Jupiter-C's ready to go but satellites as well.

And just in case you missed them, here are some of the bitter quips that ran through Washington in the immediate P.S. (post-Sputnik) days: A suggested sign over Vanguard Chief Hagen's door: "Washington slipped here." Sputnik decoded #1: "I like Ike. I like Ike. I like Ike. I . . ." And as it goes over Washington #2: "Beep, beep, beep—ha ha—beep, beep, beep—ha ha—." Real name for Vanguard—Rearguard; or Offguard . . .

There's renewed talk in Washington of a preventive war (by the same old spielers) should Russia conclusively demonstrate she's too far ahead of us technologically. And a counter-fear that Russia, or more specifically Khrushchev, might try the same just to keep himself in power. Everybody loses either way.

Chess-playing Russia aimed to sputnik on September 17 in honor of space flight pioneer Tsiolkovsky and missed by a mere 17 days. Then before the Reds had lost their advantage, Sputnik became Sputniki. This is pawn position. Next the knights, castles and bishops will move out onto the board, and finally the queen—man into space. Placing half a ton of satellite into an orbit means Russia has the rockets to do this now. Recovery of the dog alive will mean the Reds also have the other necessary knowhow. The West faces a grave and deepening danger.

After the recent AF press conference announcing the results of Project Far Side, the correspondent for one of the nation's leading newspapers remarked bitterly, "My paper detests liars." So does this page. So it aims to put the record straight: Before Sputnik, there were two official attempts to kill Far Side—once last spring when ARDC tried to shift it over to its Cambridge research division or have it eliminated, and once this summer when Asst. Secretary of AF Horner tried to kill it, saying, "AF has no business going to the moon." In both instances Air Force Office of Scientific Research fought hard and won. Second try though (when AF gave in), it categorically refused to grant more money. Thus, taxpayer paid $750,000; Aeronutronics Systems, Inc., put up $400,000 of its own funds. With Sputnik, however, top AF types hailed this as greatest thing ever; now claim full credit for dreaming it up, pushing it through and being so well prepared to hold up our country's honor. And put such pressure on Eniwetok launching teams to hurry up that three shots launched in marginal weather were failures. Credit where credit is due: To Dr. Morton Alperin, Col. Wm. O. Davis, Thomas Wilcox, Dr. S. Fred Singer, Dr. Harold Wooster, Mel White and the men of Aeronutronics

and to the Army for having low-cost off-the-shelf rockets available. In August this page wrote: "This page figures the future's for those who stick to the facts; that for those who would cite fact and fiction as one, tomorrow will be rough; end early. And speaking of facts, like dates, those who have reason to fear the first shake should beware the Ides of October."

It's still true after Sputnik as well as before . . . Let's cut the politics; let's quit trying to cover up; let's use the past solely as a classroom; and get on with the job—before the Russians atomize or Siberianize us.

Reports of Soviet 820,000-pound-thrust rocket motor may mean they're well along with T-4, their boost-glide skip bomber . . . Reds also claim to have solved manned re-entry problems with parachutes . . . Feat of atomic-powered Nautilus submarine going 1000 miles under arctic ice pack could have connection with U.S. Navy claims that fleet ballistic missiles can be fired from under arctic ice—by first melting a hole in it.

Chicago University astronomer G. P. Kuiper, using self-designed infrared spectrometer, has decided Saturn's rings are made of snow; there's CO_2 in Martian atmosphere; some of Jupiter's moons also have snow . . . Temple University Research Institute is static-testing liquid rocket engines using 100% pure liquid ozone; also firing LOX with cyanogen to achieve 4800°K combustion temperatures . . . Ultrapure titanium, zirconium, chromium, hafnium, columbium, and vanadium can be made by aluminum reduction of their oxides . . . Gold-bonded transistors show improved alpha cut-off frequencies . . . AF has run up against a stone wall in trying to find name for radar-jammer-jammer.

Anent Pentagon flip-face on giving out missile firing information, this page was warned: They can tell just as little of the truth with a flood of claims and statements as they can by keeping mum. Step's for the good, though.

There's a vernier solid-propellant engine now under development for Jupiter at ABMA-Redstone. It mounts behind nose cone with a break-away nozzle and has some connection with improved terminal guidance, hiked range or both.

The other night this page listened with respect to a dedicated space flight man who claimed our only hope of getting really ahead of Russia in the current technological race was to cut through—to go directly to the step after next and to work toward putting man into space for 48 hours and safely recovering him. There are some people in qualified positions who think that, with the right management, we could do that within 30 months, and it need not cost many billions of dollars —maybe under $200 million, in fact.

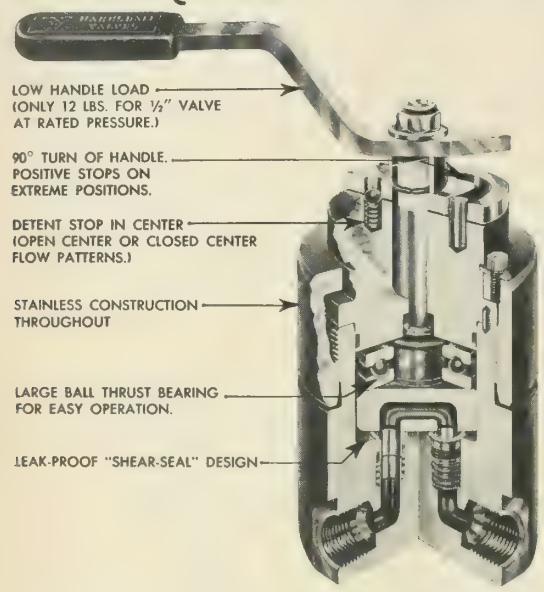
Also a suggestion that the U.S. would do well to establish something outside the military services roughly equivalent to Russia's very active Commission on Interplanetary Travel. And a hope from the people in this country who are worried that Sputnik may have been like an . . .



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Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

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This highly successful principle of extreme pressure control is fully described in "Shear-Seal" bulletin BVM-2.

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Engineers and scientists are invited to address inquiries to: Research and Development Staff, Palo Alto 7, Calif.

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Missile Business

By Seabrook Hull



THE ADMINISTRATION CAN DO NOTHING of a major nature for weeks, maybe months, to try and counteract *Sputniki*. A combination of the statutory national debt limit plus the expenditure accounting system now employed mean that there is neither money nor obligational authority for moving quickly. The Administration is hog-tied until either Congress raises the debt limit, the expenditure accounting system is dropped or tax revenues as a result of 1957 earnings start coming in. This last will result in an easing of the situation by about mid-January, 1958.

WATCH CONGRESS FOR THE TIP-OFF on the how's and when's of a major reorganization of our missile effort. Almost to a man, the House and Senate are stung (a) by Russia's technological surge ahead and (b) the Administration's efforts to laugh it off. There has been a basic loss of confidence by the American people which Congress feels probably more than the White House.

Any precise forecast of just what the next 12 months hold for our missile, rocket and space flight effort obviously isn't possible. However, you can get a pretty good idea by running down the list of probables, based on public statements by the Congressmen and on private conversations by m/r editors. Two basic things are certain: The final result will be a major reorientation of our whole space flight and missile program. And, it will mean more missile money for you—or less.

HERE'S HOW CAPITOL HILL THINKING IS GOING—a list of the actions that will be considered, some of which you can count on being adopted:

A NATIONAL ADVISORY COMMITTEE FOR ASTRONAUTICS—a wholly independent, nonmilitary agency drawing on the best from all sources to make U.S. space flight effort a No. 1 priority project, like Russia's Commission for Interplanetary Travel. Russian *Sputniki* are Russian—not Army, Navy or Air Force—satellites.

A JOINT CONGRESSIONAL COMMITTEE FOR ASTRONAUTICS, similar to that now in being for atomic energy, to keep constant watch on our progress in space fight.

A DEPARTMENT OF SCIENCE with a scientist in the Cabinet—to assure optimum efficiency in fighting Russia in the technological struggle.

A COMPLETE SERIES OF INVESTIGATIONS by several major Congressional committees, such as Appropriations, Armed Services, Government Operations and Atomic Energy. These will be aimed not so much at fixing the blame for our current lagging position as they will be aimed at finding out why and what can be done now to remedy the situation. In these hearings Congress will rely heavily on people in Government.

NO CUTBACK NOW ON MANNED AIRCRAFT until new weapons are really available, but maybe a major effort to jump way ahead with such projects as boost-glide skip bombers, manned satellites, a true space force, man on the moon, etc. This means a budget increase and a major reshuffling of current emphasis.

OPENING THE FLOODGATES OF MONEY is definitely not in the cards. Selectivity is a must. Congress will insist on it, being pretty much convinced the fault was not how much money but how it was spent.

A MAJOR LOOK AT EDUCATION is also certain. In this instance, *Sputnik* may provide the incentive to really do something about increasing teachers' pay and bringing school capacity up to population. Also, there will will be a real effort to revamp what is taught, when and how. This means more emphasis on mathematics and the physical sciences in grade and high schools. It may also mean a Federally supported system of scholarships to assure that those young people with promise get the chance to go to college.

MORE PAY AND RECOGNITION FOR GOVERNMENT SCIENTISTS is a good bet. Also, Congress may suggest that industry develop some means of rewarding its technological manpower other than by promoting them into administrative jobs.

EDISON MINIATURE -- HI-TEMP

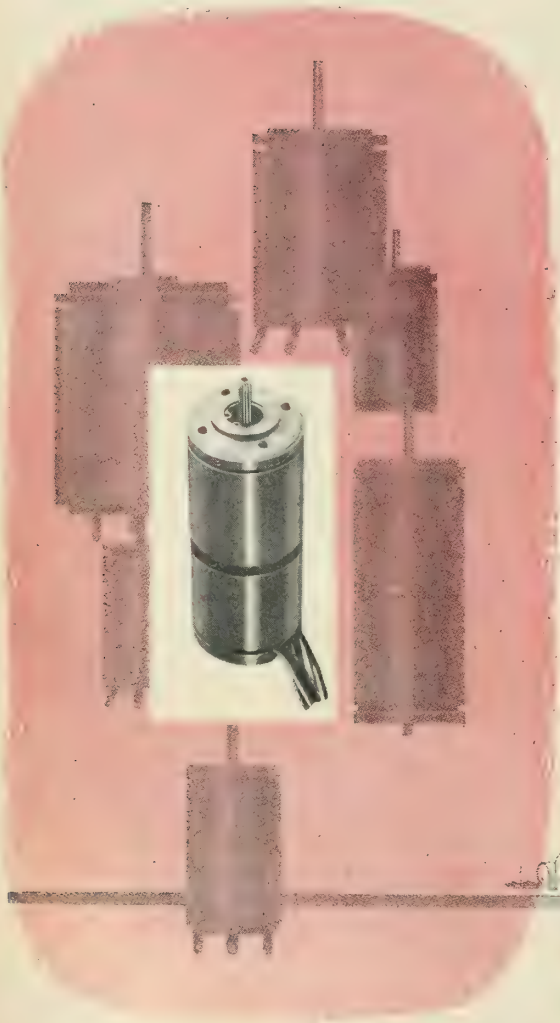
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Precision production and rigid quality control inspection have made these "customized" components possible. In addition to these special units, Edison also manufactures an extensive line of standard servo motor and servo motor-generator combinations from size 8 - up, a quality group of synchros, and custom-engineered magnetic heads for flight and ground-based analog computers.

For information about Edison precision Servos and Servo Components, write for Catalog No. 3044 . . . your copy is reserved.



EDISON SERVO MOTOR DAMPING GENERATOR

TYPE OF MOTOR	TWO PHASE SERVO MOTOR-DAMPING GENERATOR
NO LOAD SPEED (MIN. RPM)	5800
STALLED TORQUE (MIN. OZ. IN.)	.60
POWER INPUT TO MOTOR AT STALL (NOM. WATTS/PHASE)	3.5
SPEED AT MAX. POWER OUTPUT (RPM)	3300
TORQUE AT MAX. POWER OUTPUT (OZ. IN.)	.31
THEORETICAL ACCELERATION AT STALL	34,800 RADIANS/SEC.^{2}
TIME CONSTANT	.019 SEC.
POWER INPUT TO GENERATOR AT STALL (NOM WATTS)	3.5
OUTPUT VOLTS AT 0 RPM (MAX. RMS)	.019
OUTPUT VOLTS PER 1000 RPM (MIN.)	.5
PHASE SHIFT (MAX.)	10 DEGREES
DUTY	CONTINUOUS AT STALL



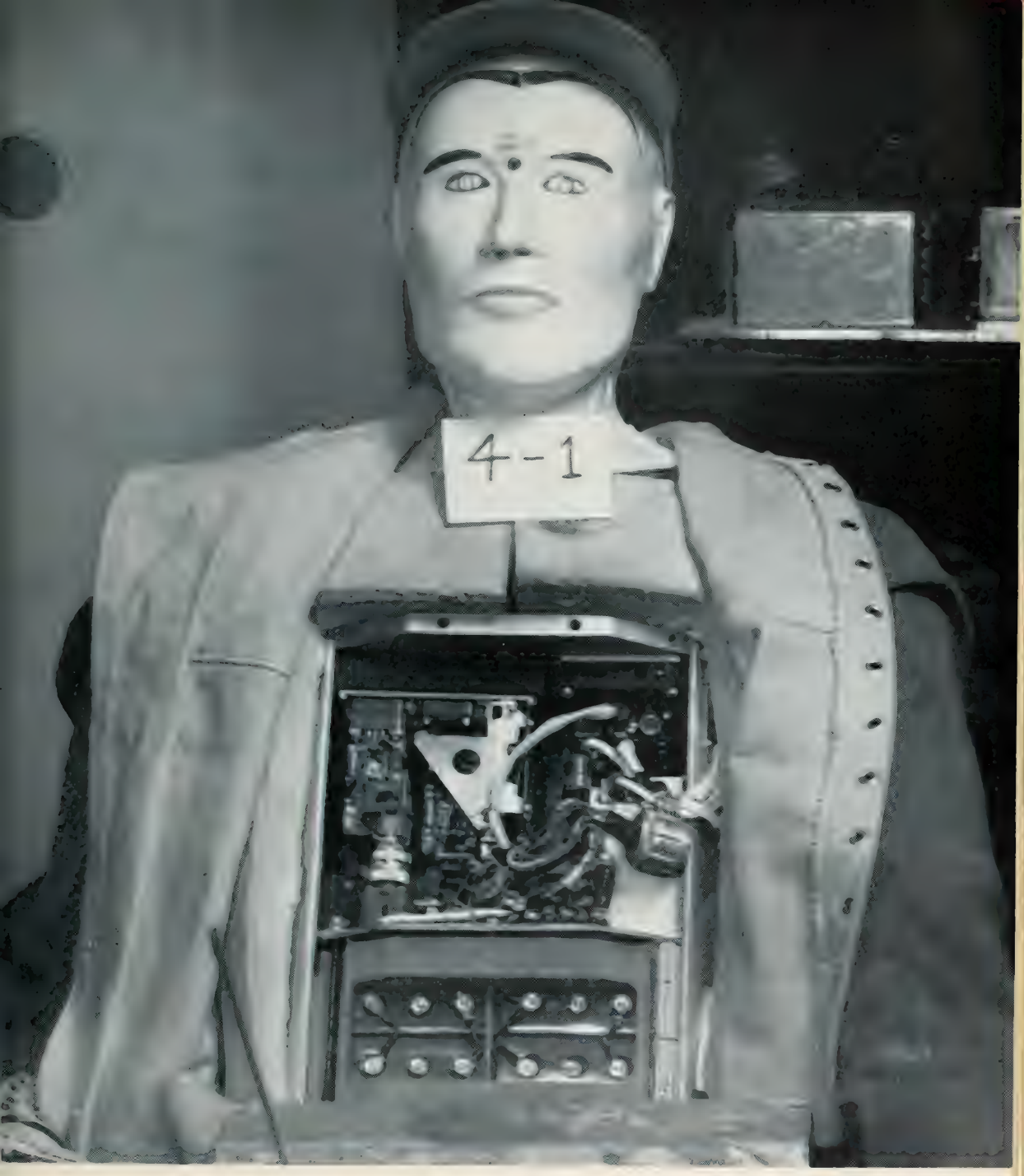
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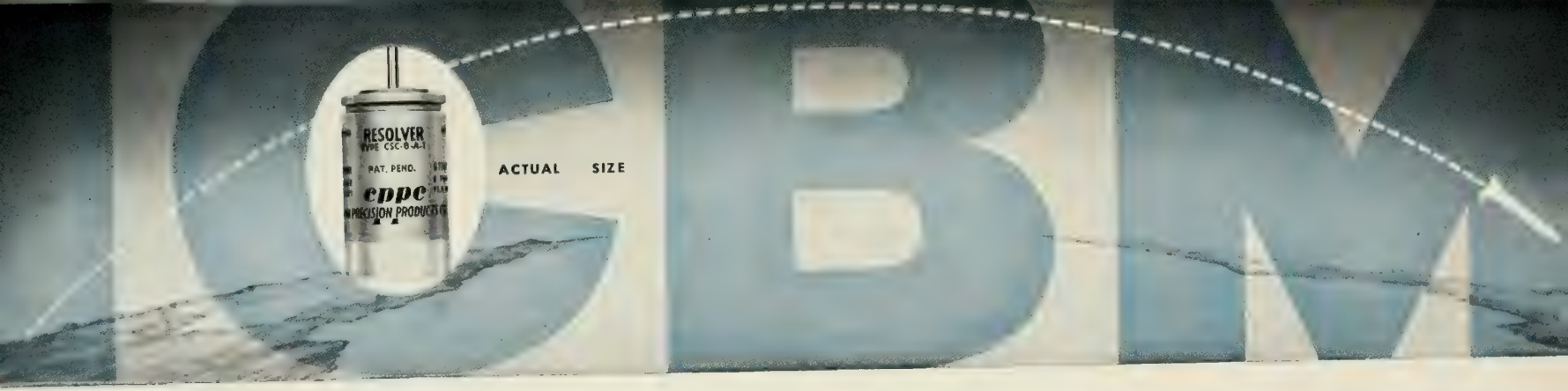
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NOVEMBER 1957



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HIGHEST ACCURACY

SYNCHRO FUNCTION	CPPC TYPE	ROTOR AS PRIMARY						STATOR AS PRIMARY						D. C. RESISTANCE		IMPEDANCE			Max. Null Voltage (MV)	Max. Error (Min.)
		Input Voltage (400~)	Input Current (Amps.)	Input Power (Watts)	Output Voltage (Volts)	Sensitivity (MV/deg.)	Phase Shift (deg. lead)	Input Voltage (400~)	Input Current (Amps.)	Input Power (Watts)	Output Voltage (Volts)	Sensitivity (MV/deg.)	Phase Shift (deg. lead)	Rotor (Ohms)	Stator (Ohms)	Zro (Ohms)	Zso (Ohms)	Zrss (Ohms)		
Torque Transmitter	CGC 8 A 1	26	100	5	11 8	206	8	-	—	—	-	—	—	37	12	54 + j260	12 + j45	80 + j20	30	7
Control Transmitter	CTC 8 A 1		—	—	—	—	—	11 8	090	2	23 5	410	9	150	24	212 + j684	22 + j115	246 + j60	30	7
Control Transformer	CTC 8 A 4	—	—		—	—	—	11 8	029	08	22 5	390	8	389	64	560 + j1860	90 + j340	640 + j190	30	7
Torque Receiver	CRC 8 A 1	26	100	5	11 8	206	8		-	—	-	—	—	37	12	54 + j260	12 + j45	80 + j20	30	30 sp.
Electrical Resolver	CSC 8 A 1	2	038	42	10 8	190	20	11 8	078	26	23 2	400	11	230	27	286 + j620	45 + j148	350 j75	30	7
Electrical Resolver	CSC 8 A 4	26	038	42	26	454	20	26	030	23	21 5	375	12	230	170	286 + j620	250 + j830	350 + j75	30	7
Control Differential	CDC 8 A 1	—	-	—	—	·	—	11 8	085	21	11 8	206	9	36	25	38 + j122	27 + j120	48 + j14	30	7
Vector Resolver	CVC 8 A 1	26	057	34	11 8	206	10 2	—	·	—	—	—	—	78	27	103 + j440	8 + j30		30	7

LOOK TO CPPC FOR SYNCHRO PROGRESS

CLIFTON PRECISION PRODUCTS CO. INC. cppc Clifton Heights, Pa.

missile electronics vol. 1, no. 2

contents

missile electronics news

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Radiation Effects On Electronics Studied

special features

Will commercial TV networks interfere with missile technology?

Limited space in the radio spectrum allocated for radio telemetry is creating a serious bottleneck in missile performance data-gathering. AAP Electronics Editor Henry Steier discusses the importance of telemetry in the transition to unmanned flight (page 149).

What are the applications of electronic components miniaturization in the missile system?

In missile evaluation the Micromation (miniaturization) concept is being applied to computing, controlling and indicating functions of complex missile systems. Sidney Herman of Waldorf Instrument Co. introduces typical applications of the Micromation system (page 154).

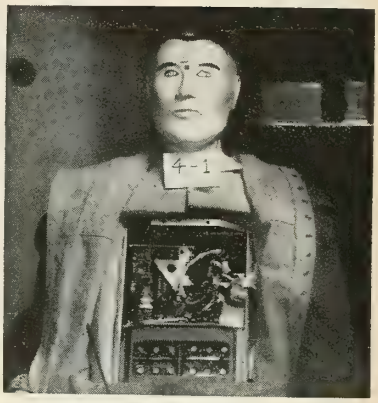
Is it necessary for specialized precision instrumentation to be confronted with continuing obsolescence?

Walter H. East, Vice President of Electro Instruments, Inc., presents one solution to the problem of obsolescence. An integrated modular instrument design is capable of combining and integrating with other instruments to form complete data-handling and automation systems (page 160).

How can missile training costs be reduced?

Expenses have been greatly reduced in the training of guided missile operators by use of electronic devices instead of actual missiles. An m/e editor, Frank McGuire, describes the system produced by Giravions Dorand, a French firm (page 166).

cover picture:



Hurricane Sam, an anthropomorphic dummy, is the star performer at the SMART test track located at Hurricane Mesa, Utah. Base cost of Sam is $3000 and when fully instrumented costs $10,000. Tests with Sam have been conducted to investigate the F-94C ejection seat at a speed of 600 mph. The dummy was ejected about 11,000 feet down the track from the breech end. However, Sam did not separate from his seat and, as a consequence, became a battered dummy on the mesa slope below the muzzle end of the track. Sam's instrumentation was designed to withstand the tremendous accelerations and impacts encountered.

departments

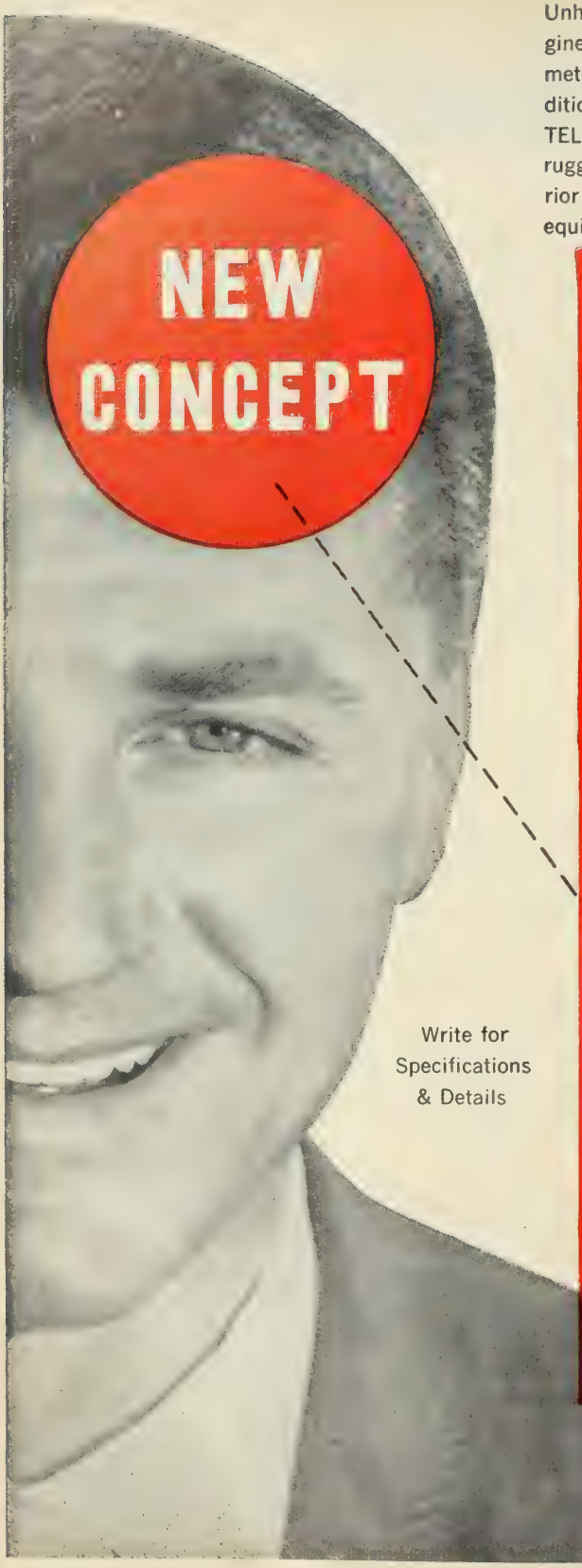
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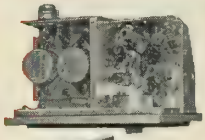
photo credits: *Air Force, Cover; Electro Instruments, pp, 160, 165; Giravions Dorand, pp. 166, 168; Radiation, Inc., pp. 149, 150; Waldorf Instrument, pp. 154, 157.*



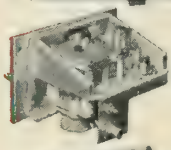
Unhampered by traditional thinking, TELECHROME engineers have developed an entirely new concept in telemetering equipment. Today's new environmental conditions and distances for missiles require new designs. TELECHROME units are unequalled in compactness, ruggedness* and dependability. Because of their superior qualities these highly efficient units are replacing equipment of other manufacture.

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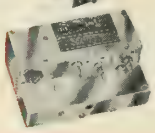
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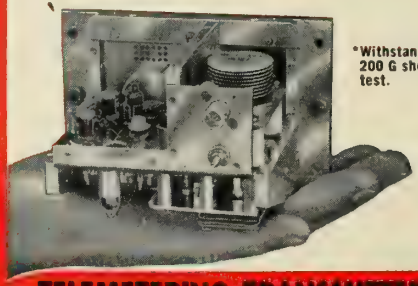


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washington briefs



BATTELLE MEMORIAL INSTITUTE in Washington says it is studying the effects of radiation damage to semiconductors under an ARDC contract. Details of the mechanism of radiation damage will aid in selecting semiconductor materials for use where radiation is a potential hazard.

NATIONAL BUREAU OF STANDARDS here is conducting research on the chemical and electrical properties of solid wax electrolyte batteries. A new field of battery research, the investigation is expected to help in understanding the phenomena that takes place in wax electrolytes subjected to electrical fields. It may also show better methods of fabricating such batteries.

TWO NEW ELECTRONIC STANDARDS for the electronics industry have been published by EIA in Washington. They concern fixed film resistors (high stability) and power filter inductors for electronic equipment.

ATOMIC ENERGY COMMISSION is asking for bids from qualified companies for preliminary studies on a compact nuclear reactor system for military use. The Department of Defense wants a mobile powerplant with moderate power rating (up to 2000 kilowatts net electric output), extreme compactness and low weight.

AIR MATERIEL COMMAND'S Brigadier General Ben I. Funk has told the West Coast Electronics Manufacturers Association that almost every subsystem of the ballistic missile is almost totally dependent on the successful application of some type of electronic hardware. In view of this, he added, "it becomes apparent that we not only want your participation in our program, but that we need it badly."

RELIABILITY AND QUALITY CONTROL SYMPOSIUM will be held in Washington from January 6 to 8, at the Statler. Papers will be presented by more than 40 industry authors and those from the military, government and research institutions. Open panel discussion on reliability definitions will be moderated by C. M. Ryerson of RCA.

RADIO ASTRONOMY has given rise to a new method of using solid-state amplifiers which give 20- to 30-db improvement over noise problems. The technique is applicable from 1500 mc to the infrared portions of the spectrum.

WESTINGHOUSE RESEARCH LABORATORY has developed a magnetic steel which allows magnetism to turn around corners, and which promises to improve the performance and simplify the construction of electrical apparatus. Named Cubex Steel, the material is a major scientific breakthrough for the electrical industry and is technically known as "cube-oriented silicon-iron." Crucial characteristic of the steel is its unusual ability to be magnetized easily in four directions, eliminating the need for piecing a magnetic core together.

TESTERS FOR ELECTRONIC TESTERS have been developed for ARDC to calibrate and adjust AF electronic equipment for maximum accuracy.

USAF IS HAVING A HARD TIME finding a term for the device to jam radar jammers. As in the anti-anti-missile-missile-missile (one that destroys anti-missile missiles), they are afraid it will be the start of a chain—such as counter-countermeasure device . . . and here we go again.

HOW BIG IS *SPUTNIK* I? Electronics experts are wondering. Andrew Ledwith, Smithsonian Astrophysical Observatory technician, figures that it is either 16.7, 33.4 or 66.8 inches in diameter. He bases his figures on the size of the antenna and the frequency it broadcasts on.

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missile electronics news

Raytheon Occupies New Facilities

Raytheon Manufacturing Co.'s missile systems division headquarters will move into a new 40,000-square-foot office and laboratory building in November. Completely air-conditioned, the building will be located on a tract of slightly more than four acres.

Raytheon is prime contractor with complete systems responsibility for both the Army *Hawk* and the Navy *Sparrow* III missiles. The division has plants or laboratories in Bedford, Lowell and Andover, Mass., and Bristol, Tenn. It also maintains flight test facilities at Oxnard, Calif., adjacent to the Naval Air Missile Test Center, Point Mugu, Calif., and at the Army's White Sands Proving Ground, N. M.

The division employs more than 6800 employees and occupies about one-third the total manufacturing space of the company.

Army Tracks Satellite With Direction Finder

The Army's newest high-power direction finder has been brought to bear on *Sputnik,* assisting in tracking its orbit as far as half way around the globe.

The high-precision radio sentinel at the U.S. Army Signal Engineering Laboratories, Fort Monmouth, N.J., is one of the more recent additions to the military electronics arsenal and is capable of pinpointing signals in any part of the earth, and far out into space.

Alerted shortly after the satellite's launching, the direction finder has sighted and followed the sphere by radio almost every time it circled the earth.

The high-precision equipment, designed to pinpoint enemy radios in combat, is in operation 24 hours a day scanning the skies for the satellite's faint radio beep. On contact, a propeller-like pattern flashes on the electronic viewing screen to give operators a direct and continuous angular bearing on the sphere.

At the same time the Army Signal Corps' latest high-power combat receivers were in operation and picked up the satellite's signal during 50 consecutive revolutions, intercepting it both directly and via the long path around the world, spanning a distance up to 24,000 miles.

Electronic Engineering Co. Leaves Canaveral

The Electronic Engineering Company of California has closed its Florida division offices and transferred the research and development operations at Cape Canaveral Missile Test Center to the company's main laboratory in Santa Ana, Calif.

Electronic Engineering designed and developed missile-range instrumentation equipment for the base, including the timing system, several digital data-transmission systems, radar installations, plotting-board instrumentation and other special work. Total cost of the work was in excess of $4 million.

The company first established a Florida division during the early development of Cape Canaveral as a test base in 1950.

Transfer of operations resulted from the reduction in field engineering needed to integrate new equipment into the instrumentation system as the field office at Patrick Air Force Base is no longer required. Operation of the test range is under the joint management of RCA and Pan American Airways.

Hallamore to Produce TV For Remote Operations

Contracts totaling nearly $300,000 for closed-circuit TV systems to monitor rocket engine and missile testing have been awarded the Hallamore Electronics Co.

The systems, two of the largest ever developed for this purpose, are being installed for the Army's guided missile center in Huntsville, Ala., and The Martin Co.'s *Titan* ICBM program in Denver.

Under the two orders, Hallamore will provide a total of 46 systems, each consisting of a receiver, a single multiwire connecting cable, and a camera capable of withstanding the white-hot exhaust blast of rockets. Each system affords intercommunication between receiver and camera locations as well as remote control of camera lens position and pan and tilt action.

Scheduled for completion early in 1958, the 24-system installation for The Martin Co. was described as one of the largest in the nation. The Army Ballistic Missile Agency installation consists of 22 systems.

Tele-dynamics Completes Philadelphia Plant

Tele-dynamics, Inc., manufacturer of telemetry systems, has completed occupation of a new plant in Philadelphia, Penna. The plant contains advanced facilities for research, development engineering and production of electronics equipment. It occupies about 100,000 sq. feet.

Aircraft Firms Pay for Missiles

Aircraft companies working on ballistic missiles are contributing a large part of the cost of the programs, according to Orval R. Cook, president of Aircraft Industries Association. In making the statement, Cook cited figures furnished by Brig. Gen. Ben I. Funk, ballistic missiles manager for AMC.

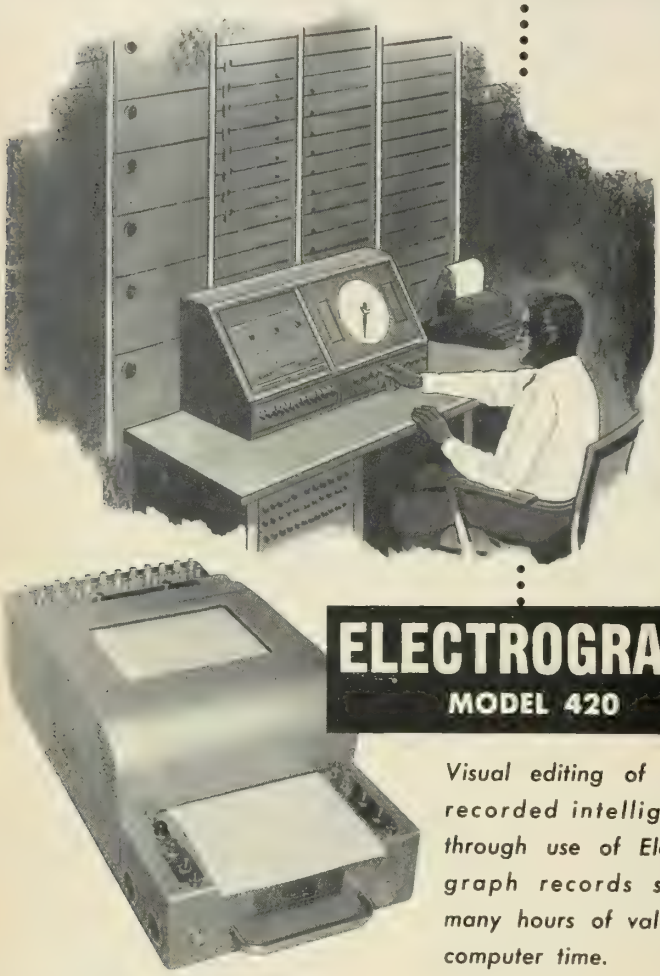
From the time that acceleration of the ICBM and IRBM programs was ordered in 1954 until July 1957, the government invested nearly $200 million in new facilities to build the weapons, according to Funk. During the same period, the contractors on on the *Atlas, Titan* and *Thor* programs provided about $100 million of their own funds for the same purpose.

Bendix Computer Division Opens Office in New York

Bendix Aviation Corp.'s computer division has opened a new district office to handle sales, service and applications of its general-purpose electronic computer and accessories in the New York area.

The company pointed out that Bendix computer division now ranks fourth in size among electronic computer manufacturers.

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Largest Analog Computer Installed at Convair

The largest direct analog computer ever built is now being installed in facilities of the Convair Division of General Dynamics Corp., Fort Worth, Texas. The $700,000 machine was designed and built by Computer Engineering Associates, Inc., Pasadena, Calif. When assembled, the computer will have a total length of 91 feet.

The unit will be used for the flexible modeling of missile and aircraft systems. The computer makes use of the analogy which exists between electrical circuit networks and physical systems. Such physical systems as mechanical, elastic, thermal, hydraulic, fluid flow, and even nuclear systems are describable mathematically by equations identical in form to those which describe electrical system networks that are either predominantly or entirely made up of passive elements—resistors, capacitors and transformers.

The capacity of the direct analog computer to represent complex systems exceeds that of conventional electronic analog computer installations. The value of the direct analogy is particularly evident in observing the effect of changes of system parameters on system behavior.

Radiation Effects on Electronics Studied

Boeing physicists have initiated a series of studies to determine the effects of nuclear energy on transistors used in the IM-99 *Bomarc* missile. From the tests, the physicists hope to establish the vulnerability of the missile's electronics system to radiation from an atomic bomb explosion.

The tests have been conducted near atomic pile sites at Arco, Idaho and Los Alamos, N.M. Transistors, operating in an electronic circuit, are exposed to nuclear radiations in these tests. Oscilloscopes show how the transistors are functioning and what changes are caused by the radiation.

Experience has shown that three things can happen to a missile in the vicinity of an atomic explosion: first, a sudden overpressure which is powerful enough to rip off wings if the missile is too close to the center of the explosion; second, a searing blast of heat that could burn up the missile; third, the effect of nuclear radiation.

Because damage from nuclear radiation has a longer range than does damage either from overpressure or from blast heat, *Bomarc* physicists are working to solve that problem as it affects transistors.

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Wanted: Graduate engineers with electrical, mechanical or electronic backgrounds. Contact Mr. Cecil Sundeen, Supervisor of Technical Employment, in care of **AC . . . the Electronics Division of General Motors, Milwaukee, Wisconsin.**

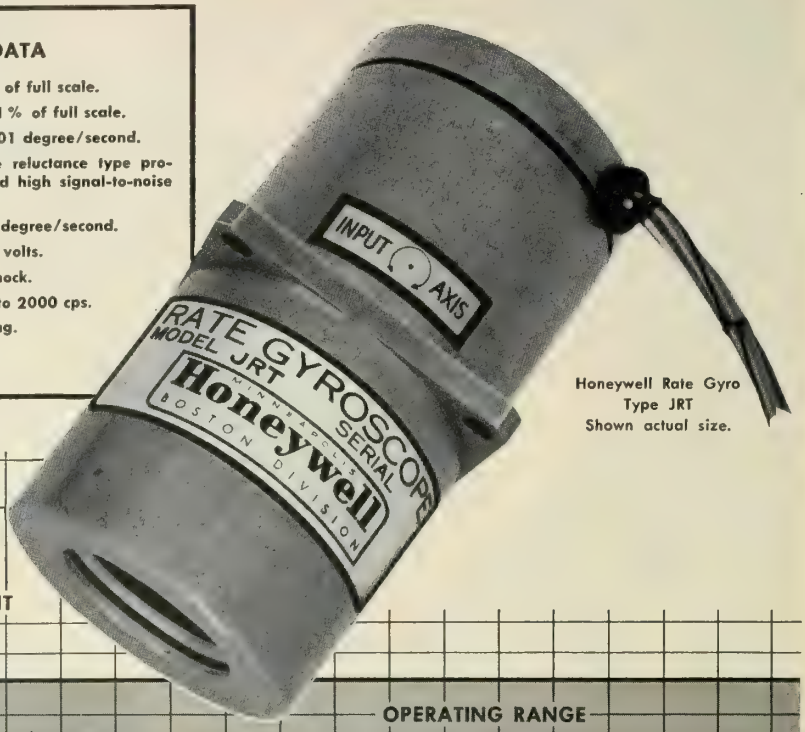
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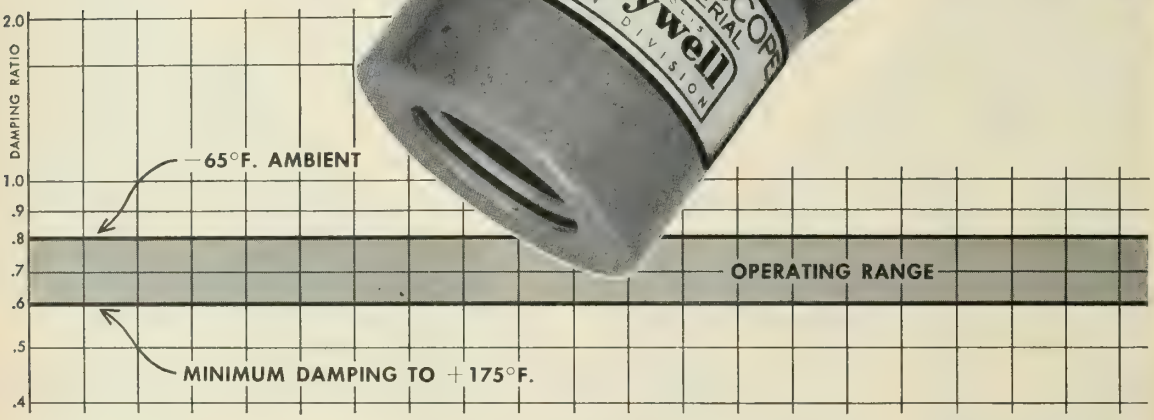
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astrionics



By Henry P. Steier

TRUE STORY OF RUSSIAN SCIENTIST A. A. Blagonravov's visit to Naval Research Laboratory's Minitrack I test facility at Blossom Point, Md. In Washington for the International Conference on Rockets and Satellites as part of the IGY, Blagonravov accepted an invitation to hear first U.S. recordings of Sputnik's signals. Listening for a while, he then remarked, "Da, I recognize the voice."

SPUTNIK (or more correctly Spootneck, which means "fellow-traveler") is causing more than anxious thoughts on the state of U.S. missile science. It's delaying to some extent development of gyros and accelerometers for our missiles. Word comes from Minneapolis-Honeywell Co. Aero division engineers that every few hours Sputnik's 20.004-megacycle signal raises havoc with some of their precision gyro measurements. Basic timing standard used by M-H engineers is Bureau of Standard's 20.000-mc transmission from station WWV. Difference between it and Sputnik's signal is only four kilocycles. This causes beats between the two. Engineers wonder how long they'll have to live with the interference.

WHOPPING LONG ANTENNAS are trailing along with Sputnik. Two antennas are used to handle the 20- and 40-mc transmissions. There are four antenna elements. Two are nine feet, six inches long; two are seven feet, 10½ inches long. Rather than mounted around the hemisphere of the satellite ball, they are mounted on one side and appear to be designed to act as trailing elements.

ALL THIS TALK ABOUT "EXACT" KNOWLEDGE of the Sputnik's orbit based on our calculations should be taken with a grain of salt. Some good data has come from optical measurements. However, considering the available optics, poor weather and the radio tracking limitations, the orbit calculations leave much unknown.

CAUGHT UNAWARES WITH ITS MINITRACK I and II stations tuned for our 108-mc frequency, the engineers at NRL have been operating under full steam to convert quickly. Main reason for choice of 108 mc was low ionospheric refraction of radio beam at that frequency. Refraction is 6¼ times worse at Sputnik's frequencies.

AT 108 MC, A TRACKING ANTENNA giving good angle resolution and non-ambiguity can be built on a 500-foot base line. Much more space is needed for lower frequencies. So we are still handicapped by the real estate thus far acquired and although our engineers are converting Minitrack I and some of the simpler type II stations to track the 40-mc frequency, the angle resolution will be limited. Higher frequency was chosen as best of the 20-40-mc evils. Refraction goes down as the square of the frequency.

DESPITE THE SUPERB PERFORMANCE of Army's *Jupiter* flights with high accuracy (Astrionics column, September), it appears the Air Force has a good argument for its use of floated gyroscopes instead of air-bearing types in the ICBM's control system. Top floated-gyro engineers say that producibility and performance repeatability problems plague air-bearing gyro producers. AF arguments for its missiles always hinge on producibility of the whole weapon system.

IS SPUTNIK'S SIGNAL CODED or not? Engineers who have watched the signal on oscilloscopes say it definitely appears to go from unmodulated to modulated wave forms. The regularity indicates it's strictly a matter of periodic switching and not atmospheric problems. A separate group of government researchers are tackling the decoding aspect but don't hold much hope for results.



NO GETTING AWAY FROM IT!

Here's the Army's answer to a major problem in U. S. defense. Hawk, recently-revealed missile, hunts and destroys invading aircraft *even at tree-top altitudes!*

Raytheon radars of unique design give Hawk its amazing low-level ability in the blind zone of conventional radars.

This aptly named 16-foot missile is launched from fixed installations for the defense of U. S. cities. Highly mobile, Hawk can also travel with fast-moving land forces, or be carried by helicopter or plane.

Raytheon, with more than a decade of pioneering in guided missiles, is prime contractor for the complete Hawk weapon system.



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telemetry for tomorrow:

TV allocations and split responsibility hamper rapid missile progress

By Henry P. Steier

IS U.S. TELEVISION broadcasting hamstringing our missile technology? One official of a key astrionics company thinks so. Many informed observers in the industry have implied it at professional gatherings.

MISSILES AND ROCKETS has learned that limited allocation of frequency space for telemetry and divided responsibility for data handling pose grave bottlenecks in achieving U.S. missile supremacy. This, from a company which has done an outstanding job getting the results of missile tests to prime- and subcontractors.

The company is Radiation, Inc., Melbourne, Fla., which since 1950 has played a significant role in that part of missile technology which might be termed "the silent service." It designs, builds and uses astrionics gear which tells missile engineers how their brain children are performing.

The business is the quiet part of an industry of ear-splitting rocket exhausts. One word, *speed,* probably keynotes a major part of Radiation's work. From the start the company dedicated itself to finding ways and means of quickly getting, and reducing to the language of computers, the data that comes from a myriad of wavy oscillographic records on flights of manned and unmanned vehicles.

Starting out as an engineering group which designed systems for acquiring data from manned aircraft, the company now finds an increasingly bigger job for itself during the transitional period from aircraft to missiles.



New, giant ICBM tracking antenna designed by Radiation, Inc. Unique feed system at center of the reflector gives conical scan. Antenna automatically homes on telemetered signals from the missile. Rate-memory circuit continues tracking during fadeout or noise period.



Conrad H. Hoeppner (left), technical advisor, and George S. Shaw, vice president for engineering, Radiation, Inc., which is equipping Air Force test range from Cape Canaveral, Fla., to Ascension Island with ICBM tracking telemetry antennas.

This is because, with man eliminated, engineers are forced to collect far more data through telemetry. As the distance over which the vehicles operate has increased, data reception problems have multiplied.

Today, Radiation is the prime contractor for the world's largest automatic tracking telemetry antennas. They were specifically designed for our ICBM program. From these antennas will come the first indication that the U.S. has a workable ICBM.

Four of the 60-foot diameter, 1000-mile range, supersensitive antennas are being built. One is already in place on the island of Antigua, BWI. The others will be installed at Cape Canaveral, Fla.; Fernando de Noronha, Brazilian penal colony island; and Ascension Island, 5080 miles from the start of the range. One will be a spare.

The extremely long range of Radiation's TLM-18 antenna system will also make it useful for satellite and interplanetary rocket programs. It has a high gain of 28 decibels and the 1000-mile range is achieved when missile-borne transmitters use 30 watts power.

Located at the focal point of the 60-foot reflector is a rotating-lens system made up of 60 metallic disks. The feed to the lens system is off center and rotated at 10 cycles per second to produce a conical scan pattern.

The lens disks are rotated together at 600 cps in front of a wave-guide feed and form an artificial lens. Result is illumination of the target area at 10 cps and an overall beam pattern about five degrees wide. The lens is covered with a fiberglass dome.

The tracking system includes a rate memory device so that during momentary signal fadeouts the antenna will continue automatically to track the target. Tracking will continue up to 20 seconds after a fadeout.

Radiation's vice president of engineering, George S. Shaw, has expressed alarm at the lack of attention which data collection and processing have been given in U.S. missile efforts.

"There is no shortage in American industrial capability to put the hunks of sewer pipe together and fly the things," he said. "It's not like putting together a complicated airframe structure such as the B-58 where we know millions of man-hours and chronological steps are needed so you cannot shortcut."

With a missile, Shaw explained, even though the full vehicle development is incomplete, you can fire it and get information. But, he contended, this is not doing the good it should.

One of the gravest bottlenecks in getting data back to engineers on missile performance, Shaw said, is the limited space in the radio spectrum allocated for radio telemetry. Legally radio telemetry has been allocated a 20-megacycle wide-band split between the 220- to 235-mc region. The myriad telemetry users must all share the same 20 mc, often on a time-shared basis, which delays tests. Some bootlegging is allowed on a noninterference basis from 235 to 265 mc.

"Now with so much of our national defense depending on these missiles and aircraft," Shaw said, "telemetry has to be used for missiles, aircraft and atom bomb tests. Every form of data collection, tied together by radio, uses the narrow assigned bands.

"This is essentially the band width that we use for three or four television stations, and almost every city of 100,000 to 200,000 has that much band width allocated to it for television for pleasure. Thus we have allocated TV bands from about 500 mc to 1000 mc, or 500 full megacycles, which we have only used on a scattered basis."

And he added, "It is completely incongruous situations like this that are degrading our technical outlook." Arguing for better government control of our band space resources, Shaw said, "Let them squander a little of this (TV) band on radio telemetry in the same way we squander gasoline and tires on Sunday afternoon.

"Certainly the Soviets have no TV-channel interference problems. If they did, they'd put them off the air. They've put the problem at a higher level of importance than we have. Let's hope we can be as dynamic in changing our ways as Russia was after 1945.

"We sort of hamstring ourselves in the way we work things out. Telemetry is especially important during this transition to unmanned flight. The cycle will reverse, however, at some point and may occur sooner than you think. Probably it will occur on the Soviet side first because of their difference in philosophy on the value of human life. The cycle will reverse back to the manned vehicle." This will not eliminate the telemetry need, but will ease the problem and enable use of man to read data.

In the 2000-mc band there are 100 mc available to telemetry users. However, use of the space is surrounded by problems. Interference with certain radars occurs. Transmitting equipment for a given efficiency gets much larger because of the microwave plumbing needed.

At 200 mc, an input of 200 watts gives an output of perhaps 100 watts. To get the same power at the higher frequency, 600 watts input would be needed. This is a big handicap when batteries or solar cells are used as in a weight-sensitive satellite or missile.

To get the same antenna gain at the higher frequency as the low, the antenna aperture must be the same. But the beam angle goes down. In the case of Radiation's 200-mc ICBM tracking antenna, the beam angle is about five degrees. If the frequency were 2000 mc, the angle would go down to one-half degree. This would seriously affect ability to track the missile and

raises the probability of its loss if its trajectory becomes erratic.

Shaw said very little money has been spent on R&D for 2000-mc telemetry. The advent of further developments in the use of the MASER (magnetic amplification by stimulated emission of radiation) might aid the efficiency-weight problem. But such developments are in the multimillion dollar bracket.

Another advantage predicted by Shaw if low-weight MASERs are built is increased missile accuracy. Net effect of using the ultra-high frequency stability of the MASER might be to increase ICBM accuracy within five miles, he believes.

Radiation together with other companies is doing whatever is possible to shorten the time lag brought about by data reduction. At this time the company uses FM/FM pulse-width modulation equipment for data transmission. On the ground this is converted to pulse-code modulation for input to the computer.

Every one of the IRBM and ICBM programs have been aided by Radiation's work either in the form of components or systems. Data-processing equipment supplied for the B-58 program was a recent contribution to the aircraft field.

The equipment assembled by Radiation is not necessarily made by the company. Most of it is purchased and modified to suit the needs of a specific system.

Shaw said, "Certainly we are not needed from the standpoint of production. We have never produced large quantities of equipment and don't intend to build a large production outfit. The nation has that capacity. What we do need is the capability to engineer specific hardware required in a small quantity. There is where Radiation fits in."

When a missile contractor is given a job to produce a missile, he does not develop new means of instrumentation. It is specifically written that he use available test-equipment facilities. He does not have R&D money for improved instruments. All he can do is repackage what is available to suit his vehicle.

"The telemetry industry has not and dares not, for economic reasons, to proceed developing lines of needed equipment. Quite frankly, there are few new instrumentation techniques that go beyond merely repackaging, stabilizing a transmitter a little better or improving the gain of a receiver.

"Beyond this, you get into millions of dollars investment, and dollar sales have not warranted that the electronic giants spend the money on R&D. So the prime sources of R&D have failed to provide new telemetry and dynamic instrumentation at the rate needed for the satellite, ICBM and moon vehicle problems," Shaw explained.

Another serious bottleneck is that radio telemetry in the United States has been a split responsibility.

First, the vehicleborne equipment is the responsibility of the prime contractor. But the missile test centers have responsibility for the data-collection equipment, and some data-reduction equipment. Some of the data-reduction job goes back to the prime contractor.

This split responsibility wastes time and missiles. This is because of hours, days and even months spent in reducing the data or transferring it to different interests, since some of the reduction is done by the prime contractor, who might be thousands of miles away.

If the contractor gets the information on magnetic tapes in oscillographic form, it must reduce the records to numbers before calculations can be made and decisions reached on a vehicle or subsystem's performance.

"The thing that gets so important here is that with our missile production capability we can fire test missiles at a fantastic rate on a weekly or monthly basis. The only thing is that with our data handling techniques it might well be three or four months before the data

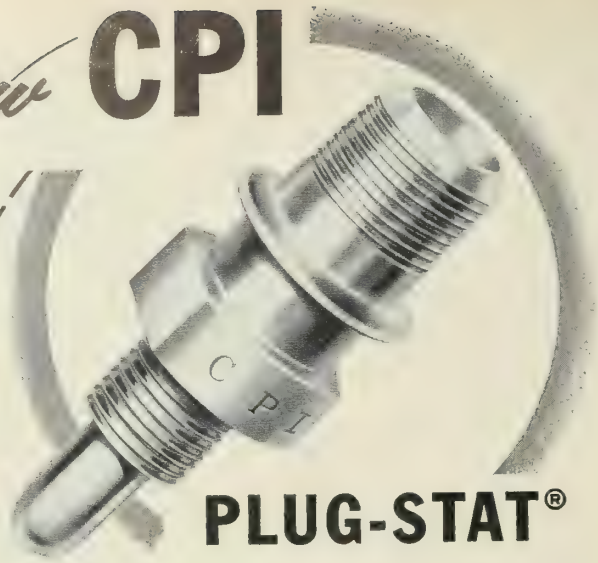


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is fully available for modification of how the next test should take place," Shaw told m/r.

And he added, "We probably partially waste two vehicles. We fire simply because we don't know enough about the first flight to go right ahead and do something immediately."

An example of how time is wasted because of limited data-processing capability is the procedure by which a missile contractor might reduce the data supplied to him on a magnetic tape.

Some companies use lines of girls who read the paper oscillographic tapes manually and put the information in digital form on a consolidated record. Punched cards are made from these, and then run through a computer.

This is not altogether necessary with today's advances in data acquisition and automatic reduction. One of Radiation's major efforts is to design and fit together systems to telemeter, process and reduce data to digital form on magnetic tapes. In this form it is compatible with high-speed input capability of digital computers.

Some companies such as AC Spark Plug and General Electric have recently built advanced data-reduction systems to shorten the time lag. Building systems for other companies to do fast data reduction is a primary job of Radiation's data systems division.

Needed badly is some form of more accurate acquisition in the vehicle. Some form of pulse-code modulation equipment in the vehicle would speed up data reduction. Next step after that would be to pick up the information in digital form.

If this were done, the digital data could be telemetered directly into a computer and the test results would be available almost immediately for assimilation by engineers.

The field for development of digital transducers is wide open, but lack of money for the R&D presents a pessimistic picture for any early big gains in this field. Radiation has entered the field of developing digital transducers because of the tremendous potential.

The company was started by its president, Homer R. Denius, and Shaw with a capital outlay of $25,000. Preliminary estimate of 1957 sales is $7 million. There are five operating divisions: research, data systems, RF, instrumentation and product. The company also has facilities at Orlando, Fla., as well as a nationwide organization.

A systems research group was recently added to the company to study potential fields of endeavor. It includes Lloyd Everyingham, James Brantley, John Doolittle, Armand Tanguay and Don Rhodes, all formerly with Cornell Aeronautical Laboratory. L. W. Sieck, formerly with AF Development and Planning Board, is also with the new group. ★

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micromation for system miniaturization

Missile applications have supplied the catalyst for coordinated miniaturization

By Sidney Herman
Waldorf Instrument Co.

RECENT efforts in missile instrumentation have concentrated on independent element miniaturization. Solving the problem of miniaturizing the overall system required more than mere selection of miniaturized elements and components. The functional unit had to be considered as an entity, and each designed with respect to the other parts in the functional system. The design process is a closed-loop in which the basis for selecting any one component depends upon feedback from other elements in the loop.

Application of this design philosophy to coordinated system miniaturization is Micromation.

The Micromation concept has been applied in missile evaluation to typical computing, controlling and indicating functions which are parts of more complex systems. The systems include ground test equipment, preliminary firing, checkout units, and analog converters used in missile guidance. It is possible for the design engineer to proceed directly from his system block diagram to procurement of functional modules after specifying inputs and outputs. The intermediate stage-by-stage design is eliminated.

A common instrumentation problem is that of servoing data. Input data may be received from any one of a number of transducers: synchro, potentiometer, strain gauge, thermocouple, etc. The desired output is a shaft rotation equal to a function of the input value, linear or otherwise.

In the normal design process, this functional block would be broken down into subunits as shown in Fig. 1. Requirements for each unit would be analyzed and performance specifications established. Some requirements would be compromised to permit use of available components.

As a result of the Micromation process, a proof-tested combination of miniaturized subunits is available and is assembled into a functional module. This module performs the desired servo repeater operation with matched subunits, in minimum size and weight, without sacrificing power, reliability or ease of maintenance.

As a further result of the Micromation process, the burden of subsystem engineering is shifted from the system designer to specialists. The functional module incorporates the latest proven techniques of miniaturization and subsystem design.

One of the first examples of a Micromation product is a completely self-contained synchro-type servo-repeater module presently in production at Waldorf. The unit, Model No. W1801, is two inches in diameter and four inches long. It contains a transistorized servo amplifier, size eight servo motor and control transformer, power supply, and gear head. One of the preliminary models is shown in Fig. 2. Each component is also constructed as a miniature modular assembly thus maintaining a simplicity of maintenance. Fig. 3 shows each of the components that, when assembled, comprise the repeater.

The complete repeater unit weighs 13 oz. and is installed in the same manner as a motor or synchro component.

Production units have been tested under varying conditions of temperature and supply frequency. Results are shown in Figs. 4 and 7.

There is an evergrowing trend toward the use of digital computing

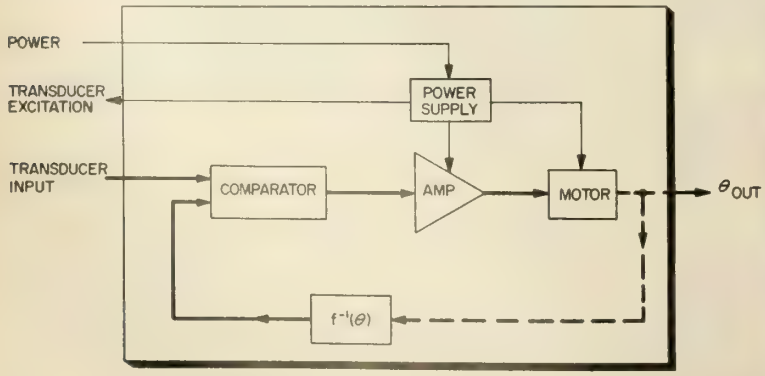


Fig. 1. A normal functional servo block would be broken down into subunits as shown.



Fig. 2. Synchro-type servo-repeater module.



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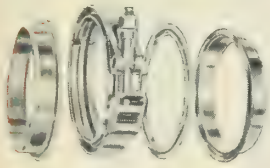
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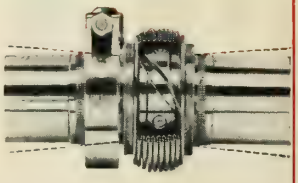
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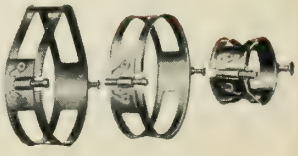
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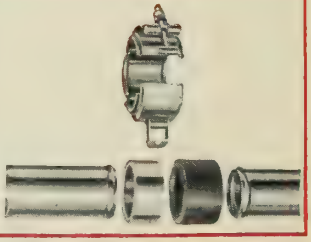
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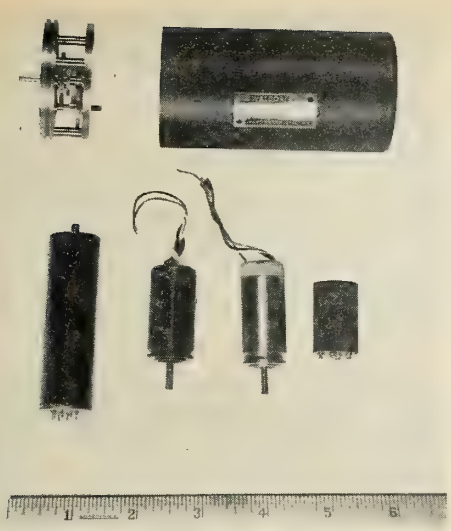


Fig. 3. Components of Model No. W1801 servo unit.

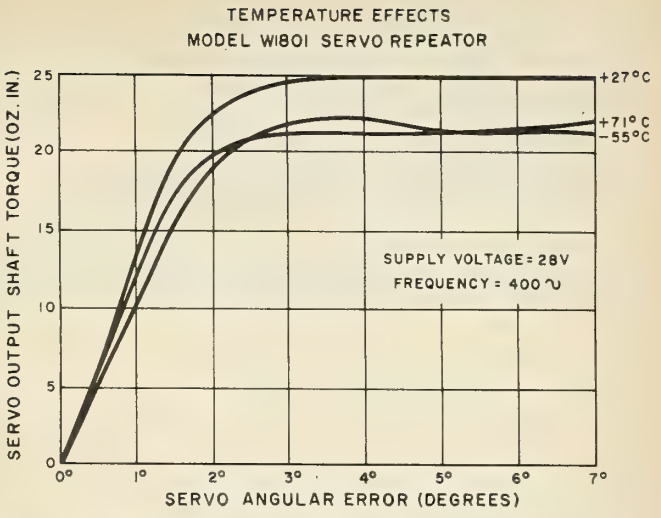


Fig. 4. Results of tests of unit of motor torque vs. input voltage.

techniques in instruments.

A common problem encountered, however, is that of converting the input analog voltages received from transducers into digitized outputs equal to a desired function of the input valve, linear or otherwise.

The treatment of the servo repeater problem, modified by addition of a digitizer as shown in Fig. 5, may be applied. For example, to convert synchro input linearly, a unit such as the Model W1801 Synchro Servo Repeater with the addition of a digitizer on its output shaft may be packaged as a completely self-contained module, each component constructed as a miniature modular assembly. The resultant Micromation package would be a "black box" with provisions of a synchro-transmitted input and a digitized electrical output.

The servo amplifier and motor requirements are satisfied by the same proof-tested components used in the repeater (Fig. 5). A servo amplifier Model W1803, presently being produced, is another result of applying the Micromation concept.

The unit, a transistorized module

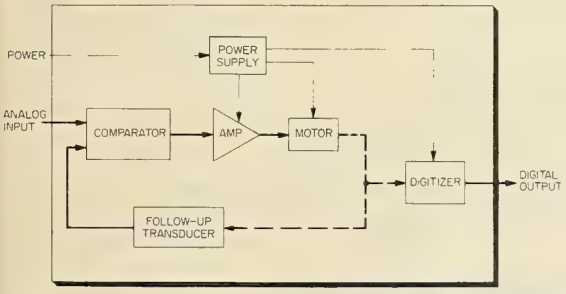


Fig. 5. Vector quantity resolved into perpendicular components.

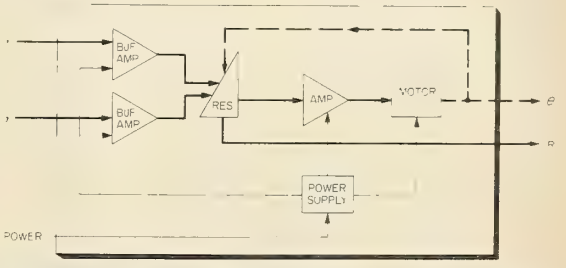


Fig. 6. W1801 amplifier tests of temperature on torque vs. voltage.

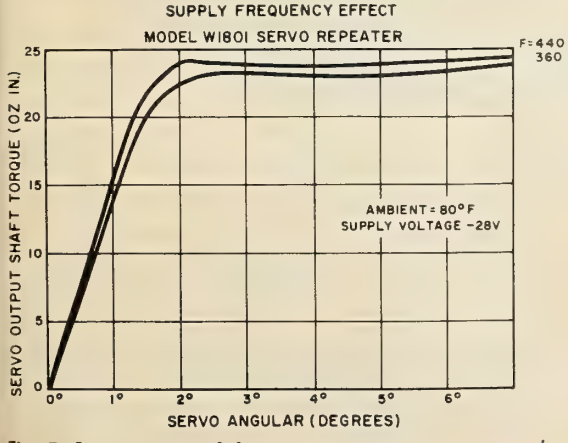


Fig. 7. Repeater tests of frequency on torque vs. servo angular.

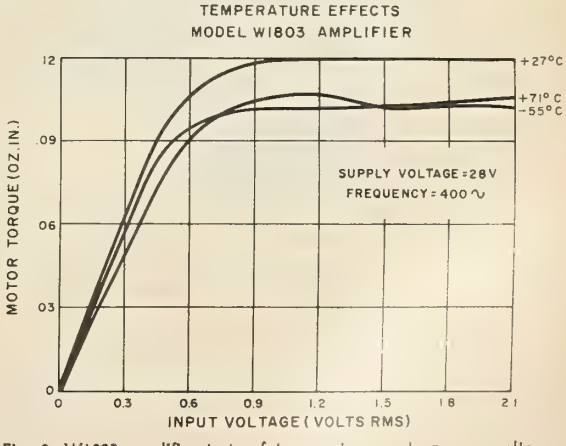


Fig. 8. W1803 amplifier tests of temperature on torque vs. voltage.

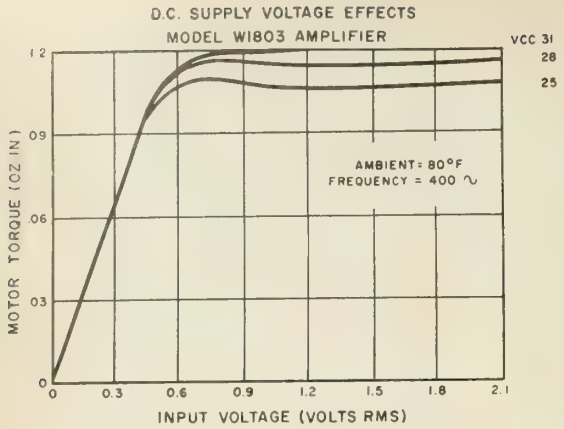


Fig. 9. W1803 amplifier tests of dc voltage on torque vs. input.

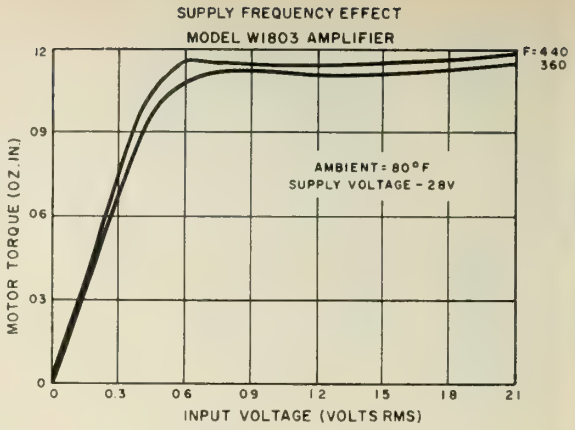


Fig. 10. W1803 amplifier tests of frequency on torque vs. input.

13/16″ in diameter and 2¾″ long, weighing 2 ounces, is designed for use with 26-volt, 400-cycle, size 8 or 10 servo motors. Capable of being mounted in any position and requiring only a 28-volt, dc power supply (at 125 milliamperes), the 90° phase shaft required for two-phase induction-type servo motors is obtained directly. Therefore, no external capacitors are required.

Production units have been tested under varying conditions of temperature, supply voltage, and frequency. The primary consideration during all these tests was the amplifier's function in the system. As a servo amplifier it is basically required to drive the motor to produce an output torque proportional to the error signal input. Thus, the motor output torque rather than output voltage was the measured characteristic of merit. Results are shown in Figs. 8, 9, and 10.

Right Triangle Solver

A problem continuously arising in analog computations is that of resolving a vector quantity into mutually perpendicular components, or, its converse, obtaining the vector quantity from its components, Fig. 6 illustrates the manner in which a Micromation module would solve the latter in a self-contained subsystem package.

The same off-the-shelf, modular servo amplifier package (Model W1803) and motor previously described, are used. The other elements within the system unit are treated in an identical manner.★

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CIRCUIT DESIGN AND TYPICAL USES OF THE "150" CARRIER PREAMPLIFIER

One of the most frequently used plug-in front ends for Sanborn 150 Series oscillographic recording systems is the Model 150-1100 Carrier Preamplifier, since with it a "150" system can record such variables as force, temperature, strain, pressure, displacement, velocity, flow, acceleration — or any variable which can be expressed as a suitable input signal by a transducer. The "1100 Carrier" will operate with a variety of different transducers and bridge circuits, which will be mentioned later on.



In the block diagram (Fig. 1), a push-pull oscillator provides an excitation voltage of about 5 v. to the transducer at a standard frequency of 2,400 cycles or optional frequencies of 600 and 1,200 cycles, using plug-in components. This excitation voltage also feeds the Balancing, Calibration and Zero Suppression circuits. (The Balancing controls allow correction of resistive and reactive signal leakage from the transducer, so that at zero load the net signal to the Preamplifier is zero. The Zero Suppression feature permits bucking out a large static load so that a small part of the load can be expanded over the full recording chart. The Gage Factor control allows the zero suppression range to be made equivalent to some convenient transducer load, or the full load rating of the transducer, and also causes the calibration signal to represent 2% of that load.) Transducer output is fed to the transformer through the Gage Factor potentiometer, across which the Balancing-Calibration-Zero Suppression circuits develop a voltage effectively in series with the transducer output. The mixer receives a suppressed carrier AM signal and re-inserts a carrier component, to make its output a conventional AM signal whose modulation represents the transducer load. The modulation signal (whose amplitude and polarity represent magnitude and direction of transducer output) is recovered by the demodulator and fed to the output amplifier, which in turn excites the Driver Amplifier and recording galvanometer of a "150" system.

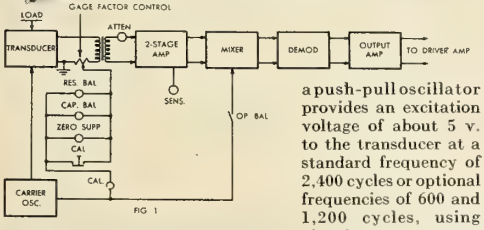


FIG 1

Transducers which may be used with the Carrier Preamplifier include strain gage half-bridges or full-bridges, commercial resistance or reactance bridges, differential transformers and resistance thermometer bridges. The transducer chosen should provide at least 18.0 microvolts per volt of excitation at the minimum load to be recorded, for a one cm. deflection; impedance should be 100 to 1000 ohms. With strain gages, normal operation provides sensitivities of 50, 20 or 10 micro-inches per inch for each cm. on the recording, depending on the number of active gages. With resistance thermometers, if 1°C. or 2°F. per cm. stylus deflection is sufficient sensitivity, the user can construct his own resistance thermometer by including a 3 ohm coil of copper wire in one arm of an equal arm 100 ohm bridge.

Helpful information about the use of transducers with the 150-1100 Preamplifier is contained in the following Sanborn RIGHT ANGLE articles (reprints on request): Coupling Differential Transformers, Aug. and Nov. 1956; Filter Networks for use with Force Dynomometers, Nov. 1956; Calibration with 1-, 2- or 4-arm Strain Gage Bridges, Aug. 1955; Theoretical and Actual Applications of Bridge Circuits, May and Aug. 1954.

Wing flutter recording to infrared research . . . with the versatile "1100 Carrier"









Today, Carrier Preamp-equipped Sanborn "150" systems are being used for frequency response tests of process control system components; to record shaft deflections of fluid mixing equipment; in infrared research . . . vehicular traffic studies . . . submarine hull vibration measurements. Applications are limited only by the transducers available.

These are applications of only one "150" front-end; *eleven* more interchangeable, plug-in Preamplifiers increase the scope of Sanborn oscillographic recording systems to meet an almost infinite variety of research, production and field testing requirements. All Sanborn "150" direct writing systems record inkless traces in true rectangular coordinates; all provide 1% linearity; Basic Assemblies — equipped with *your choice* of Preamps — are available from one- to eight-channels, packaged in vertical cabinets, portable cases, or specially modified housings.

Technical data and help with your oscillographic recording problem are always available from Sanborn.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman St., Waltham 54, Mass.

modules for digital instrumentation

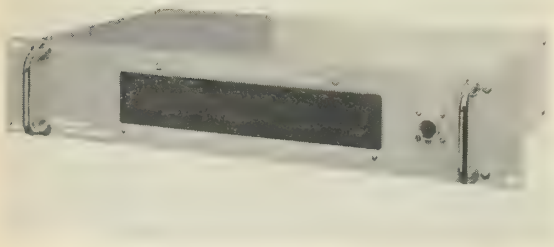
By Walter H. East, Vice President
Electro Instruments, Inc.

DUE TO THE DYNAMIC character of current expansion in the electronics industry, the specialized precision instrumentation field is more than ever confronted with the problem of equipment obsolescence. Such obsolescence is usually caused by changes in problem requirements but it is frequently occasioned by inflexibility or incompatibility in the design of the instruments themselves.

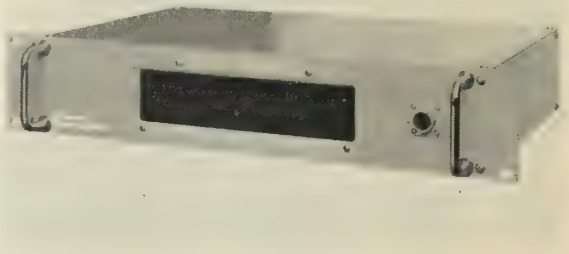
One solution to this problem is an integrated, modular instrument design. The basic modules should be capable of combining to form precision instruments as well as integrating with other instruments and machines to construct complete data handling and automation systems. Also, the development of new instruments should extend the usefulness of the instrument line and maintain a current position rather than cause obsolescence or complete loss.

There is also the obvious advantage of easy maintenance—no small problem in complicated electronic packages. With modular instruments it is a simple matter to substitute an interchangeable module and keep the system in operation.

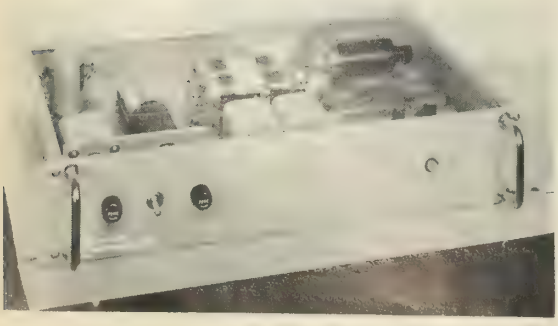
Electro Instruments, Inc. has been manufacturing a complete line of precision digital instruments for automatic measurement of DC and AC voltages, resistance, DC and AC ratios. These basic instruments can also be modified for operating with machine read-out equipment or for integration into systems. However, each change or modification entails new engineering and since customers cannot always predict future needs for their instruments, modifications at a later date are always difficult. Then, too, there are inevitable minor changes required for specific



Five-digit digital voltmeter module.



Four-digit digital voltmeter module.

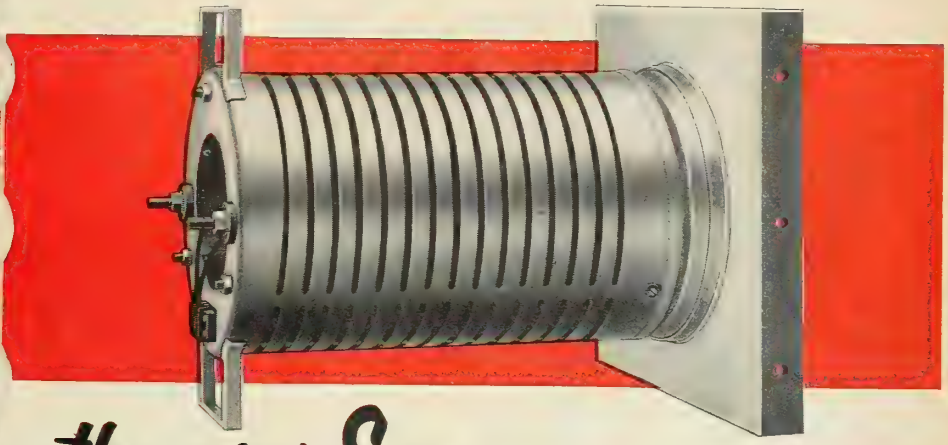




Power module for power and reference voltages and flexowriter module for sensing meter balances and operating typewriters.

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Newly designed—to meet critical space and weight requirements. Front panel makes possible cantilever mounting of several units horizontally or stacked in tiers.

Mounting panel is only 13 inches square. Overall length is 18 inches—weight approximately 18¼ pounds depending upon capacity.

Amazing efficiency! 10 to 15 KW power absorption per unit—up to 2350 BTU's of heat dissipation per pound of weight. No other type of power absorber, air or water-cooled, can begin to match this performance.

Exceptionally well suited to aircraft and guided missile testing and service equipment, this unit has many commercial and industrial applications, too.

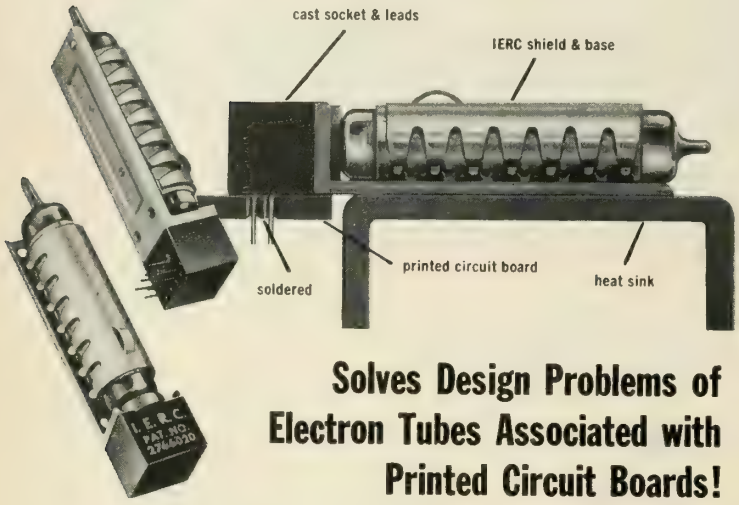
You'll want to investigate this versatile unit for your own power absorption requirements. Write today for full details and specifications.

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Solves Design Problems of Electron Tubes Associated with Printed Circuit Boards!

IERC's latest heat-dissipating tube shields for round button and flat press subminiature electron tubes solve design and performance problems of tubes associated with printed circuit boards. Standard socket and an Epoxy resin are integrally cast to the shield base. Socket leads extend from the Epoxy casting 90° to plane of base permitting direct plug-in to printed circuits for hand or dip-soldering of connections. Bulb temperatures are maintained to within 5°C of the heat sink temperature per watt of heat-dissipation when shields are attached, as suggested, to a heat sink of proper thickness for conduction or hollow duct types permitting air or liquid circulation. IERC's patented design provides maximum cooling, excellent tube retention, shock and vibration protection under severe conditions. Pertinent dimensions are to .1 inch grid layout.

Patented and Patents Pending



International

electronic research corporation

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IERC Research and Engineering experience on improving electron tube life and reliability has won industry-wide acceptance and established IERC as *the* Authority for the best answers to your tube failure problems. Write today for free information on IERC tube shields – the *only complete line available* for new equipment and retrofitting programs.

Heat-dissipating electron tube shields for miniature, subminiature octal and power tubes

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applications. The complete instrument design common in specialized instrumentation does not readily lend itself to engineering changes.

After due consideration of these problems and others learned from extensive field experience of over 1000 instruments, the new E-I modules were designed to meet the majority of the needs for digital instruments and instrumentation systems.

Each module solves a specific measurement problem and all may be combined and recombined into a variety of instruments. Auxiliary modules are available for complex systems when automatic programming and recording of test data is required. All types of printed forms, punched cards or tape may be obtained for automatic data production.

Basic Module Design

In addition to designing for maximum application flexibility, each module has been transistorized. This advanced circuit design has many advantages besides the obvious reduction in size, power consumption and heat dissipation. It also provides both new and improved specifications plus improvements in reliability and ruggedness.

The basic modules consist of a power module, four and five digit DC and resistance switch modules, AC converter and DC pre-amplified modules. Each unit is packaged in three ½″ x 19″ x 12″ standard rack cabinets. Combinations of instruments are constructed by merely changing interconnecting cables.

The heart of this system of modular units is the switch section unit. These modules enable the user to measure DC voltages from 0.1 mv to 999.99 volts and resistance from 10 milliohms to 10 megohms with an accuracy of 0.01 per cent. Either the voltmeter switch section or the ohmmeter switch section may be obtained in four or five digit models. The switch section modules are very compact and may be installed in the operating position of a control console, eliminating the necessity of a remote read-out.

The movement of the stepping switches is controlled by a new logic program which takes a minimum number of steps and reaches the final reading with a minimum of wear. The mechanical design of the switch section provides a new ease of servicing.

The power unit contains the necessary power supply, the null detecting amplifier, and reference voltage supplies for the other modular units in the system. The use of transistors in this unit has greatly reduced heating effects. The use of temperature controlled Zener

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One reason Moog makes so many servo valves so well is just what you see here—a superbly-equipped test room where every valve is put through its paces. All test apparatus was designed and built by Moog especially to test production valves for performance criteria including flow rate, frequency response, resolution, linearity, and hysteresis. This attention to quality in quantity is your assurance of reliable servo valves for your production requirements.



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Research Laboratory, Paramus, New Jersey

"...engines of wonderful efficacy not now in use."

Thus wrote Leonardo da Vinci in 1481 of his crossbow on wheels, certainly a fore-runner of the guided missile, in a letter to his friend, Lodovico Sforza, seeking employment as a military engineer.



Courtesy Harcourt Brace & Company.
Original: Codice Atlantico, Ambrosiana, Milan

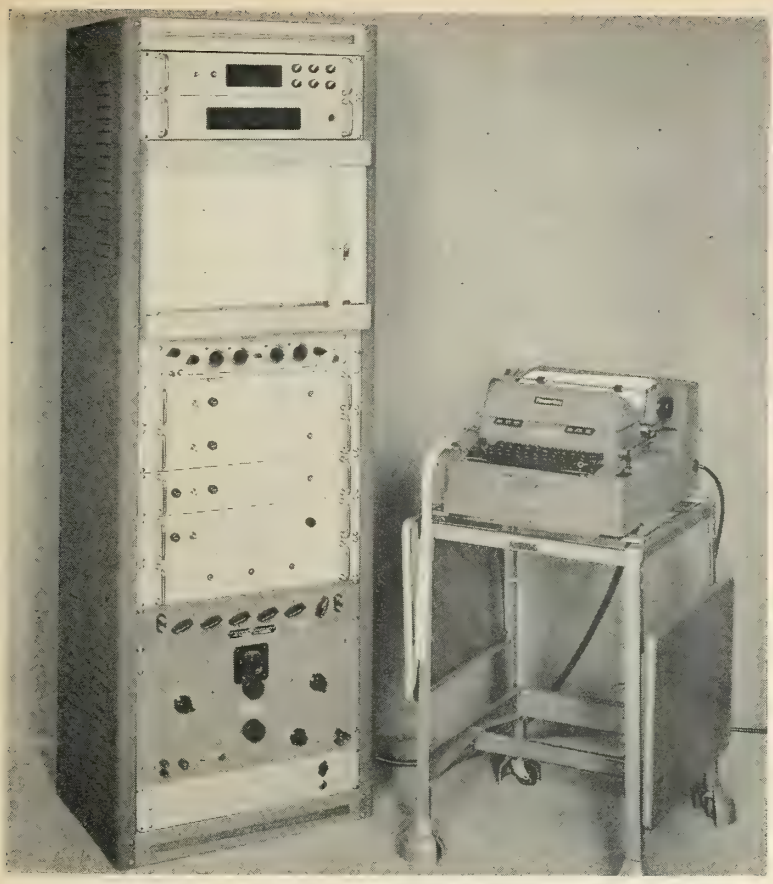
missile development at **HAMILTON STANDARD**

has created some of the industry's most intriguing openings for:

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Reply to Robert C. Main, Manager, Electronics Dept., Hamilton Standard Division of the United Aircraft Corporation, Broad Brook, Connecticut

Circle No. 104 on Subscriber Service Card.



Typical automation system constructed of standard E-1 modules. The system automatically scans and measures 400 channels of AC and DC voltages with typewriter readout.

diodes as a source of reference voltage has eliminated any dependence on a mechanically fragile standard cell. By using a transistorized stepping switch drive system, a low voltage controlled flow of power to the stepping switches reduces mechanical wear in the switch with a consequent increase in switch life. Where possible, JAN approved components are used throughout this unit for utmost reliability.

The AC converter and DC preamplifier modules enable the user to extend the use of this instrument for precision measurement of AC voltage from 30 cycles to 10,000 cycles to an accuracy of 0.1% and DC voltages from 10 microvolts to 0.1 mv with an accuracy of 0.02%.

Module System Integration

Automatic checkout systems may be easily constructed by adding scanner and print-out modules to the measurement units described above. The input scanning equipment consists of a master scanner module which contains the visual read-out and print-out facilities for automatically scanning up to 10,000 input test points. The master unit also contains a switching circuit with gold contacts for the first 100 points. To this master unit may be added up to three slave units, each of which contains 300 additional input signal circuits all having gold contacts. If desired, the user may also connect these slave units to function as parallel switch circuits to provide four-wire scanning, thereby minimizing effect of lead resistance when using a digital ohmmeter.

Readings taken automatically by the combination of the input scanning and measurement modules may be recorded in any variety of digital forms by the use of one of the print-out control modules. The printer control unit is designed to operate the Clary adding machine type of printer. Electrical typewriter controls are available for either the Underwood Servotyper or the IBM typewriter. If further automatic data reduction is required, the information may be recorded on punched tape by the use of Flexowriter units. The IBM control units enable the user to record data on punched cards for processing by computing equipment.★



Circle No. 106 on Subscriber Service Card.

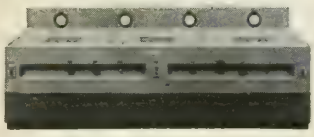
TE-5



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SOME TERRITORIES OPEN FOR REPRESENTATIVES

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visual trainer for AT missiles

By Frank G. McGuire

REALISTIC TRAINING for realistic cost has been provided for the SS.10 and similar antitank missiles by Giravions Dorand, a French firm. The model DX-40, a cine-simulator, uses motion pictures, a computer and remote control units to provide troop training in wire-guided missiles.

The device enables operators to direct missiles onto a moving target under realistic field conditions while an instructor observes the exercise. The cost of the entire unit is about $57,000, showing a marked economy over usual training methods.

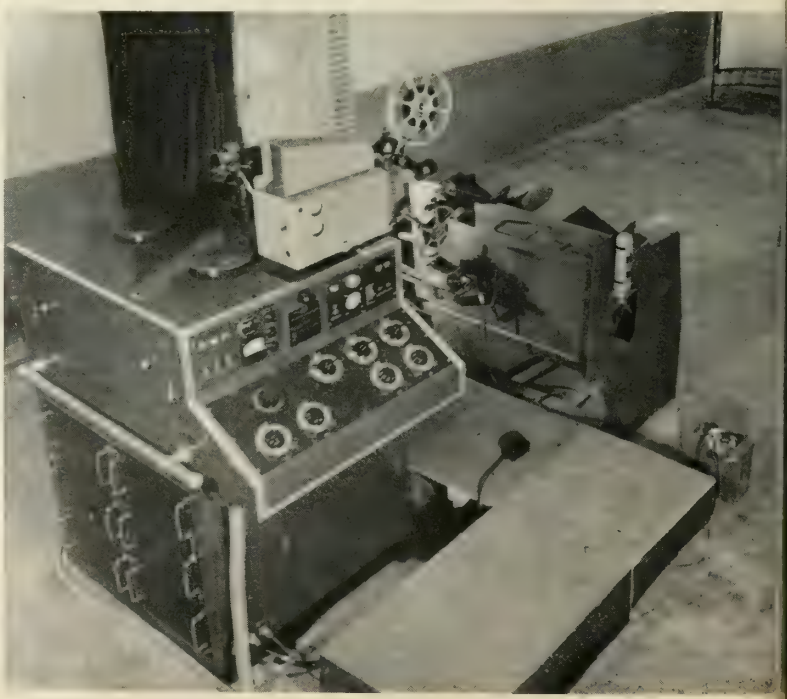
A moving target is displayed on a panoramic screen by the projector. A luminous spot also projected upon the screen represents the missile as seen by the operator. The luminous spot is remotely controlled by the student and corresponds exactly to the position of the missile at all times.

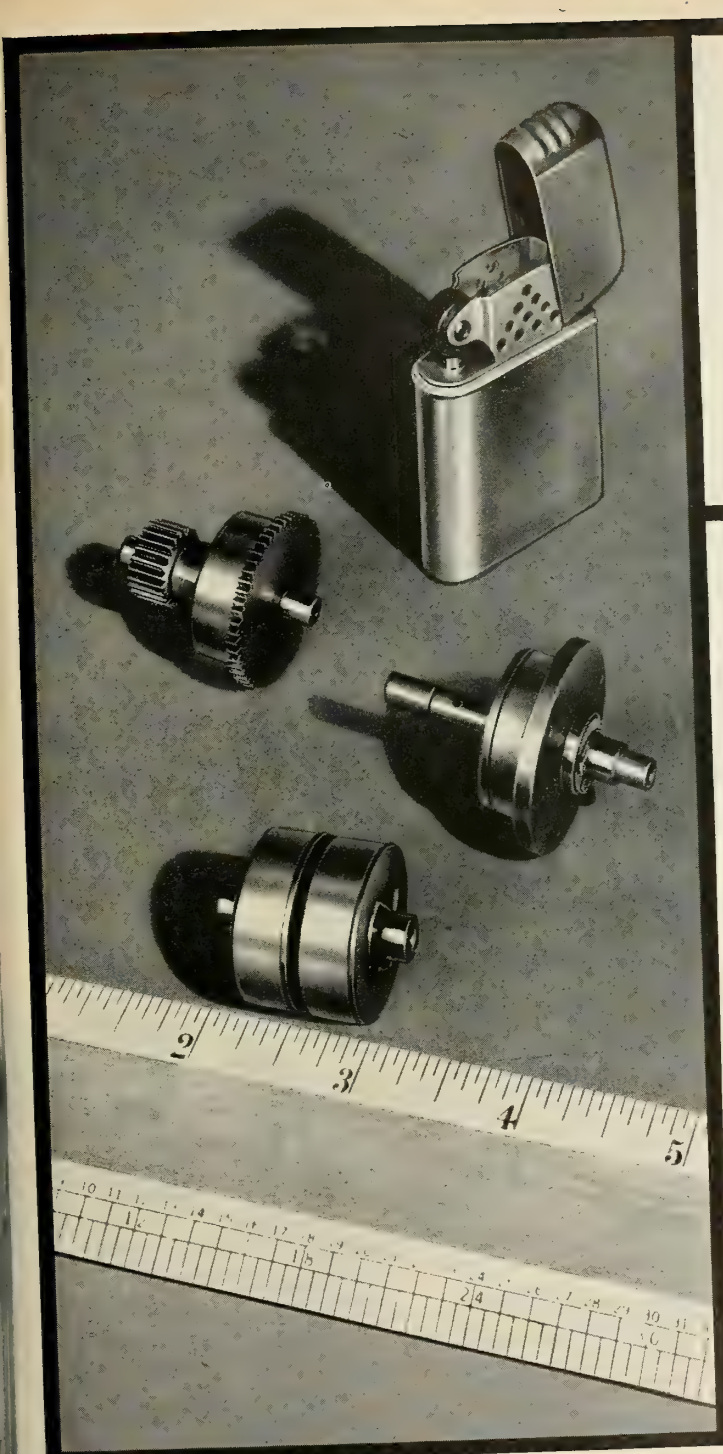
An optical cam system continuously determines the distance between the operator and target, and simultaneously computes the distance between the operator and missile. When these two distances become equal, a special device stops the simulator, freezing the target and missile images. This allows assessment of the exercise—target hit or missed, depending on spot coincidence with target image.

The system allows the instructor to follow and usefully instruct the student during the exercise. He may freeze the action at any time in order to point out particular faults, make corrections, then continue the action.

The device is composed of several units: the main cabinet, housing the

Visual trainer supplants much more expensive method of using actual missiles.





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An accessory gas turbine manufacturer uses a Formsprag clutch as a disengaging device on a starting mechanism.

If you would like to know more about how Formsprag clutches may be of help in solving your design problems, why not have a talk with a Formsprag engineering consultant?

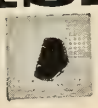
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58-G

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computer, on top of which is mounted the target projector and the missile projector. The front face of this main unit carries the starter and control panel as well as the setting-up console.

A separate cabinet houses the electronic equipment of the simulator, and the panoramic screen is placed about six to 11 feet in front of the student, who holds the remote control box.

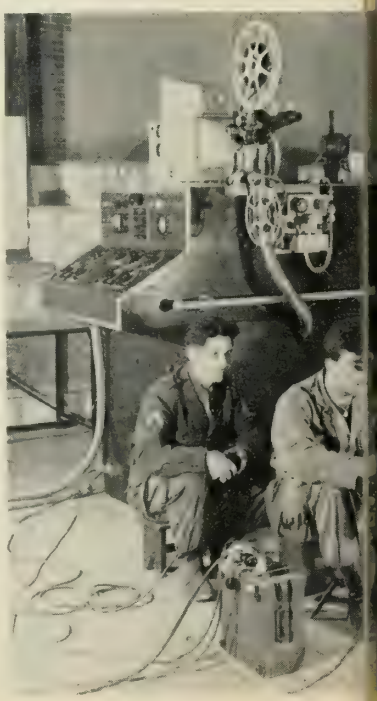
The first of these units, the main cabinet and the electronic cabinet, are ruggedly constructed for disassembly and transport by rail, road, sea or air. Special packing cases are provided with the machine.

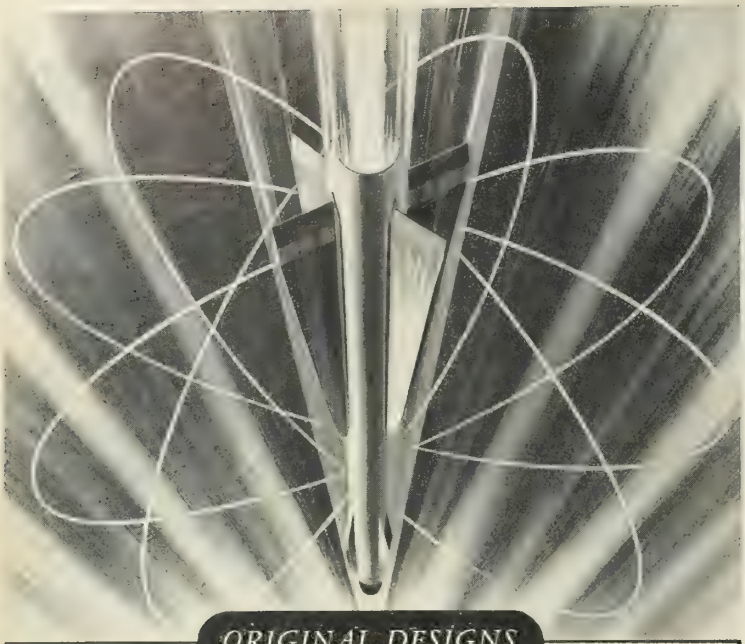
A Debrie projector is used with a mercury-vapor lamp. The projector is equipped with an instantaneous stopping device, allowing a still picture to be seen, and a reverse-running control. CinemaScope projection is obtained by use of an adjustable hypergonar projection lens.

The missile-tracer projector, controlled by the computer, produces a light spot whose size and intensity diminish automatically with increasing "distance" from the operator.

Installation of the DX-40 requires a minimum floor space of five by nine yards, and installation in a trailer is possible. Maximum power required for operation is four kva at 220 volts, ac, single-phase. Unpacked weight of the simulator is about 2400 lbs. ★

Instructor can monitor the exercise, stop the equipment and point out student mistakes.



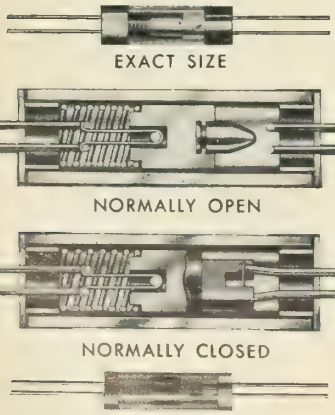


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calendar

NOVEMBER

Fourth Institute on Electronics Management, Automatic Data Processing System, American University, Washington, D. C., Nov. 4-8.

Joint Military-Industry Guided Missile Reliability Symposium (limited to those with Secret security clearance), Pt. Mugu, Calif., Nov. 5-7.

Aeronautical Communications, Third Annual Symposium, Hotel Utica, Utica, N. Y., Nov. 6-8.

Plastics for Airborne Electronics, Regional Technical Conference, Society of Plastic Engineers, Los Angeles, Calif., Nov. 11.

IRE Third Instrumentation Conference, Atlanta Biltmore Hotel, Atlanta, Georgia, Nov. 11-13.

EIA, IRE, Radio Fall Meeting, King Edward Hotel, Toronto, Canada, Nov. 11-13.

IRE, Mid-America Electronics Convention, Municipal Audit., Kansas City, Nov. 13-14.

National Aviation Trades Assn. Annual Convention, meetings with National Air Taxi Conference, Maintenance Council and Aerial Applicators, Hotel Adolphus, Dallas, Texas, Nov. 13-15.

TWE Fifth Annual Convention, Hotel Statler, New York City, N. Y., Nov. 13-15.

IRE, New England Radio and Electronics Meeting, Mechanics Hall, Boston, Mass., Nov. 15-16.

AIEE Magnetism and Magnetic Materials Conference, Sheraton-Park Hotel, Washington, D. C., Nov. 18-21.

Aviation Distributors and Manufacturers Assn., 30th Meeting, Sheraton Cadillac Hotel, Detroit, Mich., Nov. 21-22.

DECEMBER

American Society of Mechanical Engineers, Annual Meeting, New York, Dec. 2-5.

IRE (Philadelphia Section and the Professional Group on Military Electronics) and the Human Factors Society of America on "Human Factors in Systems Engineering," Penn-Sherwood Hotel, Philadelphia, Pa., Dec. 3-4.

IRE, AIEE, ACM, Eastern Joint Computer Conference, Sheraton-Park Hotel, Washington, D. C., Dec. 8-11.

1957 Eastern Joint Computer Conference and Exhibit, Sheraton-Park Hotel, Washington, D. C., Dec. 9-13.

JANUARY

Electronics Reliability and Quality Control, Fourth National Symposium, Hotel Statler, Washington, D. C., Jan. 6-8.

APRIL

ASME Div. of Instruments and Regulators Conference, University of Delaware, Newark, Delaware, Apr. 1-3.

ASME, Maintenance and Plant Engineering Conference, Penn Sheraton Hotel, Pittsburgh, Pa., Apr. 14-15.



HONEST JOHN artillery rocket depends on G-E electric heating blanket (inset) to bring missile to uniform operating temperature before launching.

HONEST JOHN FIRING SHOWS HOW . . .

General Electric Specialty Heating Maintains Propellant Temperature

Successful launch—and flight—of the Honest John depends upon exact propellant temperature at the moment of firing. A General Electric heating and insulating blanket—which shrouds missile from nose to nozzle—provides and maintains that temperature!

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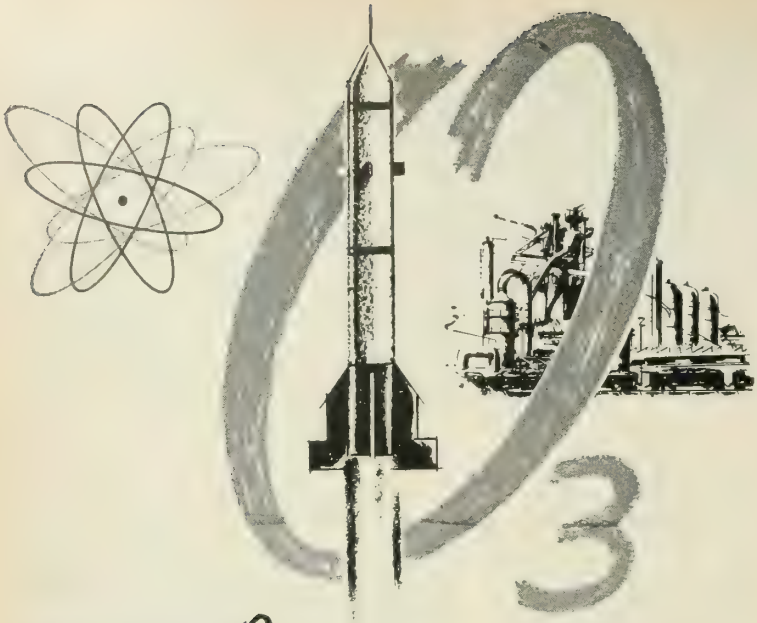
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- *Chemical synthesis reactions demanding specificity and purity in the oxidant.*
- *Removal of cyanide or phenol from wastes.*
- *Oxidation of oleic to azelaic and pelargonic acids (replaces chromic acid.)*
- *Improving oxidation characteristics of mineral oils.*
- *Elimination of many industrial and sewage odors.*
- *Purification and elimination of undesirable taste, color, and odor in municipal water supplies.*

. . . and a host of new applications still being researched.

If your process calls for an oxidant, it is almost certain that Welsbach ozone will do the job better and at less cost. Why not contact Welsbach.



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people

John F. Hicks has been appointed assistant to the general manager of Fairchild's guided missiles division. He will be in charge of public relations and will edit the division house organ, MISSILE NEWS.

C. Hart Miller has been elected executive vice president, general manager and a director of Sierracin Corp. of Burbank. He resigned as vice president, administration of Northrop Aircraft's Northrop division to accept the new position.

Robert E. Honer has been appointed chief electronics engineer at Convair San Diego.

Dr. Edward Lilley is leaving the Naval Research Laboratory to serve as assistant professor of radio and rocket astronomy at Yale University. This marks the first time that Yale has offered courses in these subjects

Roy A. Long, research engineer at Stanford Research Institute, was elected a fellow in the Audio Engineering Society in recognition of his work in communication systems.

David Eaton has been named to the newly created post of vice president of marketing at Reaction Motors, Inc.

Arch Wallen, appointed factory manager at Northrop Aircraft's Northrop Division, will direct production of the *Snark* SM-62.

T. F. Dixon, chief engineer at North American Aviation's Rocketdyne division, has been named to a special committee on propulsion to provide technical information to the Department of Defense.

Ramo-Wooldridge has elected three new vice presidents. They are **Dr. Ruben F. Mettler,** associate director of the company's guided missile research division and director of the *Thor* IRBM program; **Dr. Burton F. Miller,** director of the communications division; and **Milton E. Mohr,** group director of the control systems and Boston divisions.

Ralph J. Leppla has been appointed supervisor, and **Thomas A. Peterson,** design engineer of Leland Electric Co. Division of American Machine and Foundry Co. The appointments are in the newly created static regulator and control design department.

Gen. Ira C. Eaker has been named director of Eastern offices of the Douglas Aircraft Co. He has been vice president of Hughes Tool Co. for the past ten years.

Datran Electronics has appointed **Allen J. Edwards** as director of customer relations. He was formerly with Coleman Engineering Co.

Robert P. Crago has been named director of engineering for IBM's military products division. He has been replaced as general manager of the division's Kingston, N. Y. plant by **Richard J. Whalen.**

P. R. Perino has joined the staff of Allegany Instrument Co. as project engineer. He formerly was with Aerojet-General, Phillips Petroleum's rocket fuels division and at Redstone Arsenal as instrumentation engineer.

Henry S. Forrest has been appointed director of government service engineering and manager of the eastern office of Control Data Corp.

William H. Starbuck has been named sales manager of Elgin National Watch Co.'s micronics division.

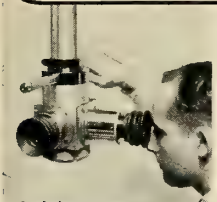
Stanley Waxman has been appointed assistant vice president of operations at Grand Central Rocket Co. Other appoint-

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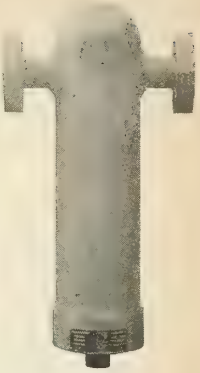
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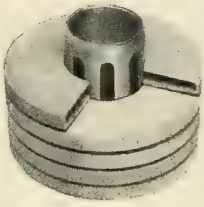


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ments at the company are **H. L. Thackwell,** vice president, and **Angus M. Scott,** assistant director of projects.

Wilson W. Petty has joined Titanium Fabricators, Inc. as chief engineer. He was previously with North American Aviation.

J. Vance Holdam, Jr. has been appointed vice president in charge of operations at Laboratory for Electronics, Inc.

Thomas F. Watson has joined the Arnoux Corp. as a senior field engineer. Prior to joining Arnoux, he was chief of instrumentation at the USAF rocket test facility, Edwards AFB.

Luther C. Ringer has been named production manager at Narmco Mfg. Co.

Dr. Robert B. Costello has been appointed assistant manager of the materials department at Aerophysics Development Corp.

Directing Exide's new missile applications department will be **Rear Adm. W. H. Ashford** (USN, Ret.) and **G. S. Hartman.** Missile engineering manager will be **H. A. Fuggiti,** while **J. J. Sullivan** continues as missile production manager.

John R. Townsend was appointed special assistant to the Assistant Secretary of Defense for Research and Engineering. He will also serve as the director of the Office of Fuels, Materials and Ordnance.

Joseph O'Reilly is the new general manager of the Ferroxcube Corp. of America.

Fischer & Porter Co. has announced the appointment of **Edward H. Muhleisen** as manager, aircraft and missile industry division.

International Business Machines Corp. has appointed **Horace W. Thue** director of manufacturing planning. He was formerly manager of the missile and commercial aircraft division at Douglas Aircraft Co.

Everett M. Patterson has been elected president of the Bulova Research and Development Laboratories, Inc. He was also elected to the board of directors.

Philco Corp. has appointed the following scientists to manage various phases of its government and industrial division: **J. Forrest Bigelow,** radar and radio systems; **F. J. Bingley,** audio-video data systems; **C. P. Woodward,** missiles and advanced tactical systems; and **Ralph Deutsch,** fundamental techniques.

John T. Gorham, formerly with the Secret Service and agent in charge of the White House detail, has been named manager of the industrial security department for Bell Aircraft Corp.

Robert G. Clark has been appointed vice president and treasurer of Epasco Inc., manufacturers of electronic data control equipment and systems.

RCA's electron tube division has appointed **C. J. Hollatz** manager of commercial operations.

Douglas C. Vest has been named director of research and development for Redel Inc. He was formerly in charge of applied interior ballistic research, Aberdeen Proving Ground, Maryland.

Robert A. Lehman has been appointed executive vice president, general manager and a member of the board of American Electronics, Inc.

Robert W. Olson has been named vice president, research and engineering, of Texas Instruments Inc. and **E. O. Vetter** as general manager of TI's industrial instrumentation division.

John T. Castles has been appointed

sales manager for the silicone products department of the General Electric Co. Formerly manager of rubber market development, Mr. Castles succeeds **Jerome T. Coe** who has become the department's marketing manager.

Robert M. Fritz has been appointed marketing manager for the General Electric Co.'s missile and ordnance systems department.

Chance Vought Aircraft, Inc. has promoted **Kelly G. Smith** to quality control manager and **George Gasper** to chief tool engineer.

Laurence E. Russell has been appointed director of marketing for the organic chemicals division, Olin Mathieson Chemical Corp.

M. B. Jobe has been appointed manager of customer relations of Goodyear Aircraft Corp. where he will supervise all customer relations division heads.

Richard D. Evans has been appointed as government sales manager for the Special Tube Operations of Sylvania Electric Products, Inc., where he had been special sales representative for the company's semiconductor division.

Edwin S. Hoffman has joined Stavid Engineering, Inc., as contract representative in the firm's Washington, D.C. office.

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MISSILES AND ROCKETS, published monthly at Harrisburg, Pennsylvania, for November, 1957.

1. The names and addresses of the publisher, editor, executive editor, and business manager are: Publisher, Wayne W. Parrish, Washington, D. C.; Editor, Wayne W. Parrish, Washington, D. C.; Executive Editor, Erik R. Bergaust, Washington, D. C.; Business Manager, Leonard Eiserer, Washington, D. C.

2. The owner is: American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington 5, D. C.; Wayne W. Parrish, President, Washington, D. C.; Albert H. Stackpole, Vice-President, Harrisburg, Penna.; E. J. Stackpole, Director, Harrisburg, Penna.; Leonard Eiserer, Exec. Vice-President and Secretary-Treasurer, Washington, D. C.; Eric Bramley, Vice-President, Washington, D. C.; Robert R. Parrish, Vice-President, Chicago, Ill.

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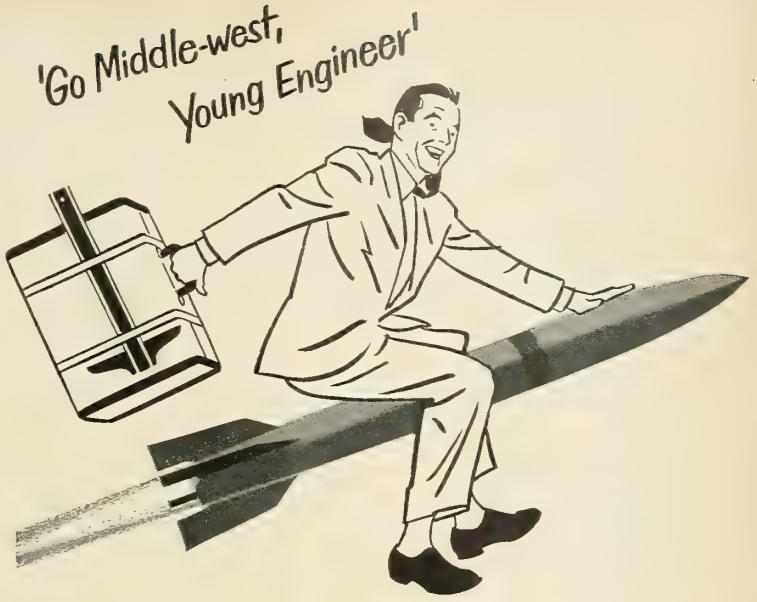
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5. The average number of copies of each issue of this publication sold or distributed through the mails or otherwise to paid subscribers during the 12 months preceding the date shown above was: 11,872

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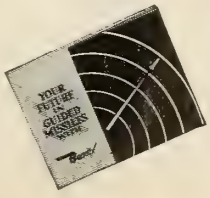
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MISSILE LITERATURE

ELECTRICAL RESINS. A properties chart for electrical resins, giving the mechanical and electrical details of the major Epocast electrical resins used in the industry, has been published by Furane Plastics Inc.
Circle No. 150 on Subscriber Service Card.

ELECTRONIC COOLING. Basic design principles of electronic cooling, covering methods of air convection and metallic conduction, are treated in an 8-page folder published by McLean Engineering Laboratories.
Circle No. 151 on Subscriber Service Card.

THERMAL STRESSES. Said to be the first book on thermal stresses to cover all phases of the design problem of elevated temperatures in supersonic airframes. Material in the book is applicable to nuclear reactors, rocket motors and engines, missile structures and similar designs. McGraw-Hill Book Co.
Circle No. 152 on Subscriber Service Card.

ELECTRON ACCELERATOR. A traveling wave linear electron accelerator, designed for research in nuclear and solid state physics, is described in a brochure offering the machine for sale or lease to physics and electronic laboratories. Applied Radiation Corp.
Circle No. 153 on Subscriber Service Card.

CRYOGENIC ENGINEERING. Sixteen-page booklet published on the Cryogenic Engineering Laboratory of the National Bureau of Standards. U.S. Department of Commerce.
Circle No. 154 on Subscriber Service Card.

ELECTRONIC DESIGN. Booklet published for use by designers of electronic equipment covering design points to be considered. Includes common faults found in equipment, human engineering suggestions and points for proper parts application. U.S. Navy Electronics Laboratory.
Circle No. 155 on Subscriber Service Card.

VACUUM IMPREGNATION. Six-page data publication giving technical information on processes to guarantee pressure tight castings. Cycles for batch and internal pressure impregnation, including simultaneous bonding of dissimilar materials, are outlined and diagrammed, step by step. Western Sealant Co.
Circle No. 156 on Subscriber Service Card.

INSTRUMENTATION TAPES. Magnetic tapes for instrumentation recording are the subject of this illustrated bulletin dealing with six types of tapes for use in telemetering and airborne recording. The bulletin contains charts listing properties and factors to consider in the selection of a tape. Minnesota Mining and Mfg. Co.
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PORTABLE POWER PACKS. Operation of portable hydraulic power units providing fluid ground power to actuate and replenish hydraulic systems is described in a bulletin issued by Greer Hydraulics, Inc.
Circle No. 158 on Subscriber Service Card.

THERMOCOUPLES AND EXTENSIONS. Chart containing color codes and calibration symbols for thermocouples and their extension wires plus pyrometer wire resistance figures. Thermo Electric Co., Inc.
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STAINLESS STEEL. A chart for ea identification of government specific tions on stainless steel, including chem cal analysis requirements, specific forms and nearest corresponding SA AISI, and AMS type numbers. Pat A. Frasse & Co., Inc.
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TITANIUM. Monthly series of "Minu Readers" covering subjects of intere to design engineers. Number one the series deals with prices, to be f lowed by one on availability figur Titanium Metals Corp.
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HYDRAULIC RESEARCH. This volu was compiled from reports by vario hydraulic and hydrologic laboratories the U.S. and Canada. Each proje is described briefly, and the prese status, results and publications on t project are listed. National Bureau Standards.
Circle No. 169 on Subscriber Service Ca

THERMOCOUPLE GLAND. Illustrat folder shows features of midget therm couple glands, including positive se characteristics, temperature ranges a other information. Conax Corp.
Circle No. 170 on Subscriber Service Ca

HI-TORQUE BOLTS. A 4-page brochu has been published describing t advantages, applications, materia strength characteristics and tools f the hi-torque bolts of Hi-Shear Riv Tool Co.
Circle No. 171 on Subscriber Service Ca

MICROWAVE FERRITE DEVICES. R prints have been made of the bulle on microwave ferrite devices which d scribes phenomena, components a other information regarding the Sperry Gyroscope Co.
Circle No. 172 on Subscriber Service Ca

INSTRUMENTATION CABLES. Deali with cables for telemetering, da recording, circuit-control testing a electronic computers, this illustrated page bulletin gives specifications, col coding data, and other technical i formation. Rome Cable Corp.
Circle No. 173 on Subscriber Service Ca

TITANIUM REPORT. A 202-page ill strated report on titanium and its us in pigments, welding rod coatin ceramics and fibreglass has been issu by the Department of the Interior.
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PROGRAMMED CENTRIFUGE. D tailed specifications, including electric physical and performance characteristi are presented in a 14-page brochu on a rocket flight simulator. Featur and advantages, typical test runs a data, detailed description and an o lined dimensional drawing are also cluded. The Magnavox Co.
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INERT ATMOSPHERE GENERATO Bulletin contains flow charts, co analyses, and applications of the in gas system produced by Gas Atmo pheres, Inc.
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INFRARED DETECTORS. Eight-pa technical data bulletin covering infr red photoconductors and includi graphs and tables on performance. I frared Industries, Inc.
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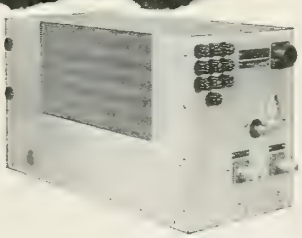
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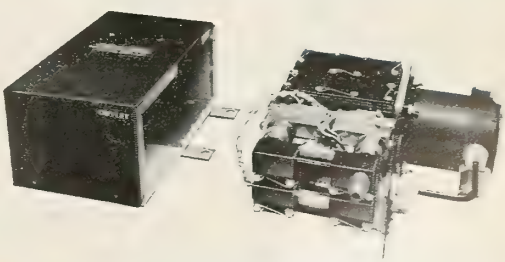
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AN AMERICAN AVIATION PUBLICATION

DECEMBER 1957

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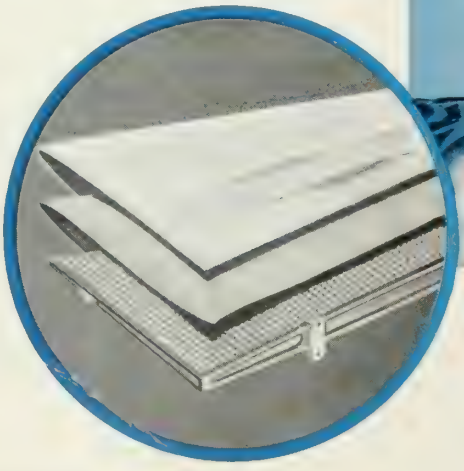
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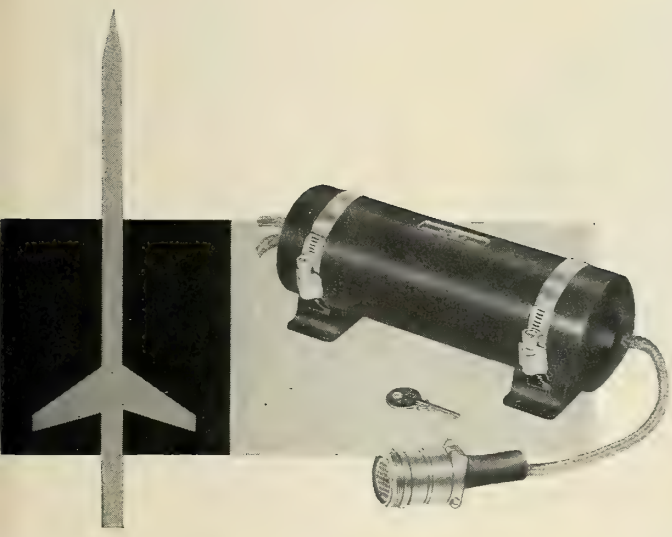
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*Aircomb, a lightweight sandwich core material, is a proprietary product of Douglas Aircraft Co.

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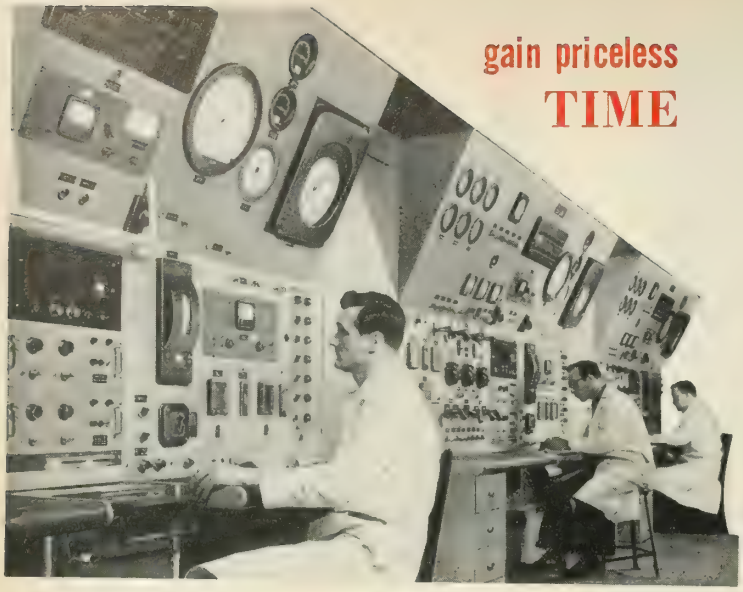
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Magazine of World Astronautics

December, 1957 Volume II, No. 12

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Jupiter, the Army's IRBM, resembling a huge artillery shell, leaves its launching pad at Cape Canaveral, Fla. *Jupiter* and its Air Force competitor, *Thor*, will both be put into production to bolster the U.S. and NATO nations' missile arsenal. This is the first outstanding result of the *Sputniki* launchings. Defense Secretary McElroy decided that although neither of the missiles is fully developed, "they are at a point where it is possible to make a sound decision to program additional production for operational purposes."

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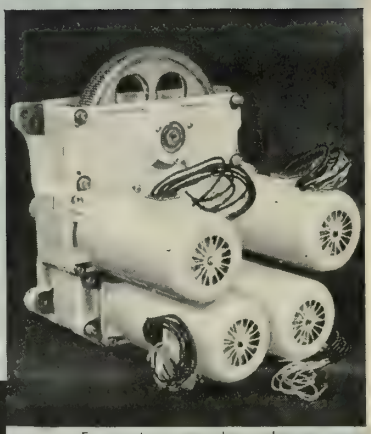
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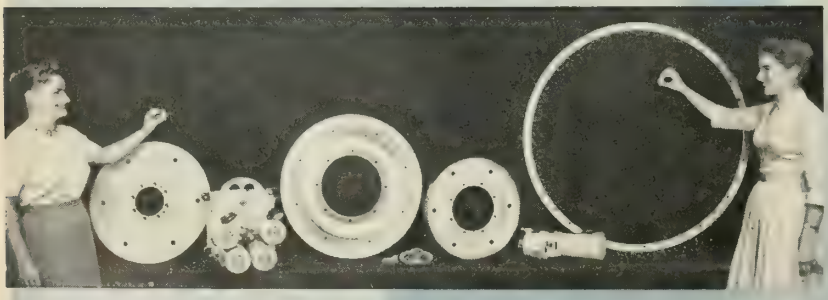


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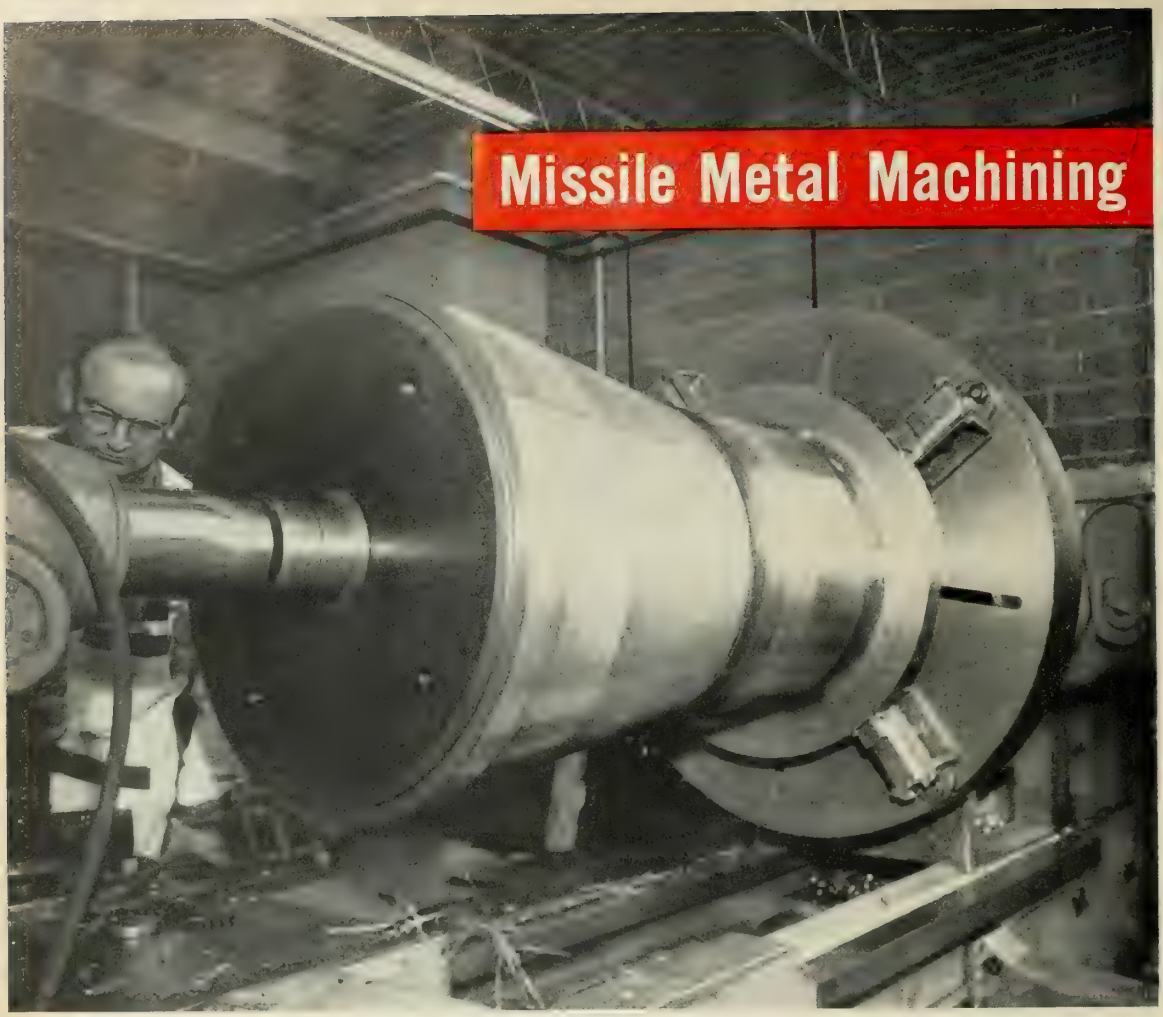


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Let's Listen to the Wise Men

At this particularly critical time in national affairs it is appropriate to analyze what the prophets of science have told us, to analyze the reasons why we paid them so little heed, and vow that our mistakes of the past will not be perpetuated.

The list of scientific and educational leaders who have warned, advised and pleaded with our military, legislative and executive planners for a change in direction is endless. Mere reflection on our woes—investigations, more reports, more committees—is not the answer. Such proceedings are very costly and, if mainly politically motivated, tend only to confuse the basic issues.

Certain names stand out. Dr. Hagen asked top priority for *Vanguard,* but his request went unheeded. Dr. Wernher von Braun has time and time again stressed the impossibility of maintaining the valuable research teams when forced to subscribe to wild variations in budget and personnel policy.

Reports were written by Dr. Louis Ridenour urging a divorcement of research from engineering management. Unsolicited recommendations by the score have been made by men of the stature of Vannevar Bush. Driven to frustration, capable Trevor Gardner simply decided to quit.

These warnings and recommendations are not new. Of great significance now are the prophesies of Dr. Theodore von Kármán, written in 1945 at the request of the late "Hap" Arnold. Von Kármán's report clearly cited the following needs: research training of officers, assignment at top staff level of officers with science training, a large budget apportionment for research in the basic sciences, changes in the military personnel rotation system, removal of scientists from under civil service personnel management, early emphasis, not on the development of hardware then in being, but on ramjets, exotic forms of propulsion, aerodynamics at high Mach numbers, rocketry and the unmanned missile for delivery of nuclear weapons.

Dr. von Kármán's prognosis was frighteningly accurate. He recognized that no long-range program could succeed unless the proper climate and conditions for its success were provided. We have not provided this climate. We have failed to recognize the challenge of Soviet science.

Let us now analyze the basic resistance to the continually urged programs. Let's do something about them. We know that procurement of science by current regulations is poor. We know we are losing trained government personnel. We know we have neglected the support of research and education. We know we have overinvested in wrong facilities.

We have been told this time and time again. We have been warned. We have investigated. Now let's listen carefully to our scientists and our planners, and, if nothing else, take action on the obvious problems which can be remedied now.

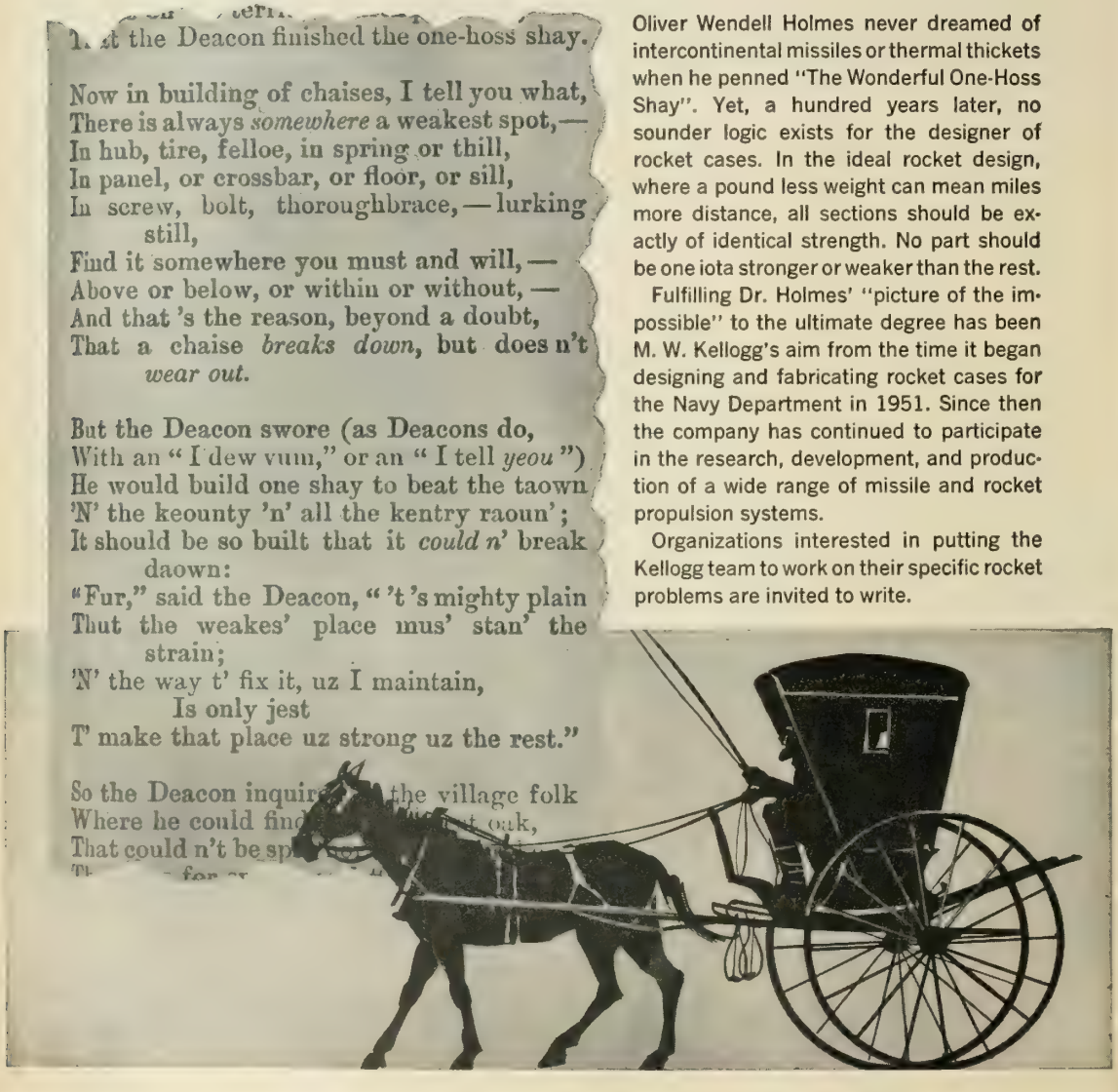
Finally, let us not forget that the wise men have told us over and over again that teachers' salaries have for many years lagged behind those of other fields. This is a grass-roots community problem which must be solved and is dependent on the general will of the public.

There is a decline in high school mathematics and science courses in this country. These courses are largely elective in American schools. There are no electives in the Russian high school system. The Russian student is basically trained to serve the State. If the State has need for more persons in a given field, the field is expanded to provide a sufficient number of people.

This is not Russia, thank God, but in the long run—without a sober change in our national thinking about what our priorities in national effort should be—we must eventually face losing the race to a nation far less complacent than we, just as intelligent, and whose youth is driven harder to the task of study and given the tools with which to work.

ERIK BERGAUST

Rocket Logic in Retrospect



...t the Deacon finished the one-hoss shay.

Now in building of chaises, I tell you what,
There is always *somewhere* a weakest spot,—
In hub, tire, felloe, in spring or thill,
In panel, or crossbar, or floor, or sill,
In screw, bolt, thoroughbrace, — lurking still,
Find it somewhere you must and will, —
Above or below, or within or without, —
And that 's the reason, beyond a doubt,
That a chaise *breaks down*, but does n't *wear out*.

But the Deacon swore (as Deacons do,
With an " I dew vum," or an " I tell *yeou* ")
He would build one shay to beat the taown
'N' the keounty 'n' all the kentry raoun';
It should be so built that it *could n'* break daown:
"Fur," said the Deacon, " 't 's mighty plain
Thut the weakes' place mus' stan' the strain;
'N' the way t' fix it, uz I maintain,
Is only jest
T' make that place uz strong uz the rest."

So the Deacon inquir... the village folk
Where he could find... oak,
That could n't be sp...
Th... for ...

Oliver Wendell Holmes never dreamed of intercontinental missiles or thermal thickets when he penned "The Wonderful One-Hoss Shay". Yet, a hundred years later, no sounder logic exists for the designer of rocket cases. In the ideal rocket design, where a pound less weight can mean miles more distance, all sections should be exactly of identical strength. No part should be one iota stronger or weaker than the rest.

Fulfilling Dr. Holmes' "picture of the impossible" to the ultimate degree has been M. W. Kellogg's aim from the time it began designing and fabricating rocket cases for the Navy Department in 1951. Since then the company has continued to participate in the research, development, and production of a wide range of missile and rocket propulsion systems.

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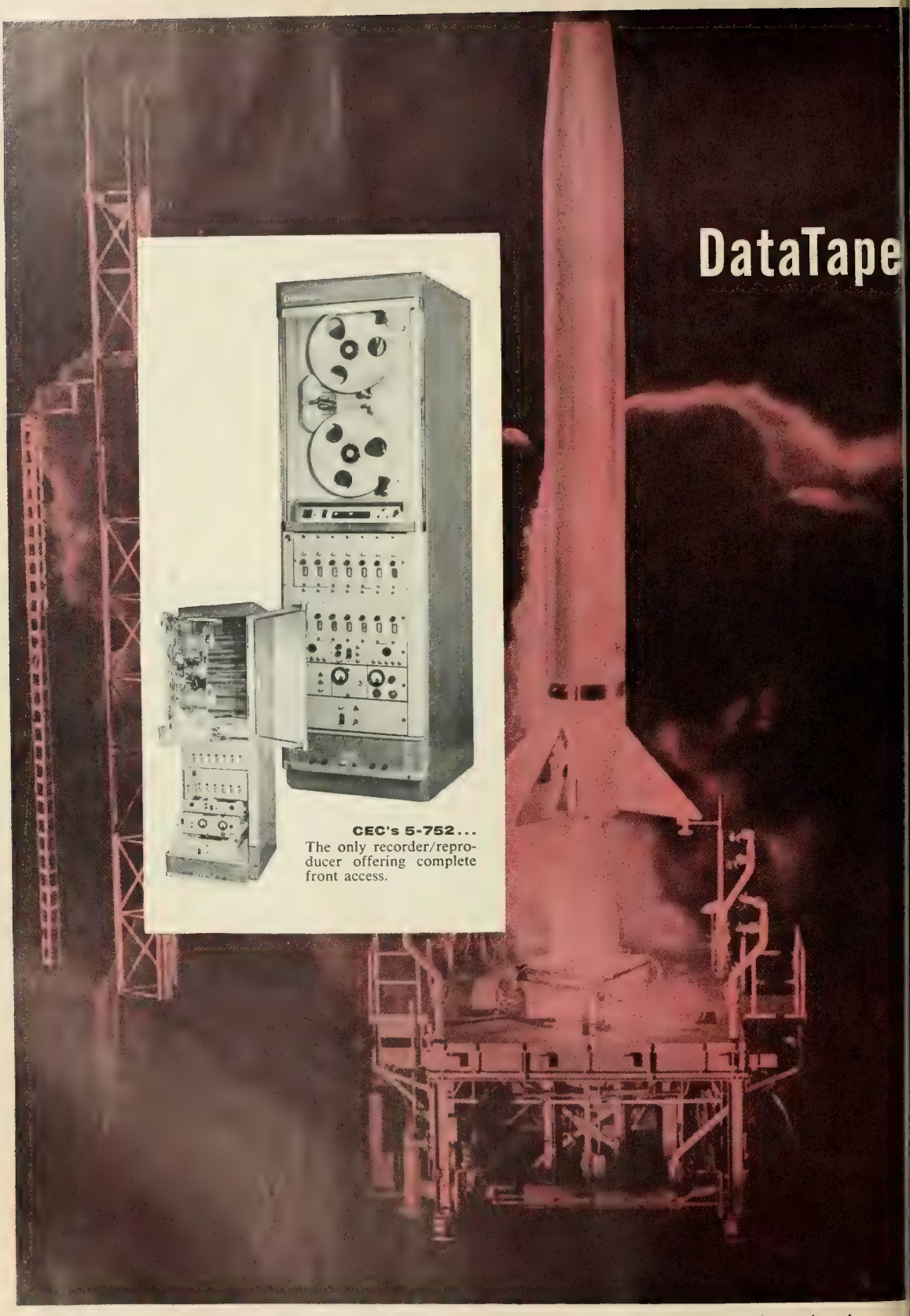
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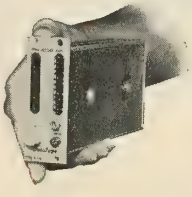
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ENGINEERING REPORT

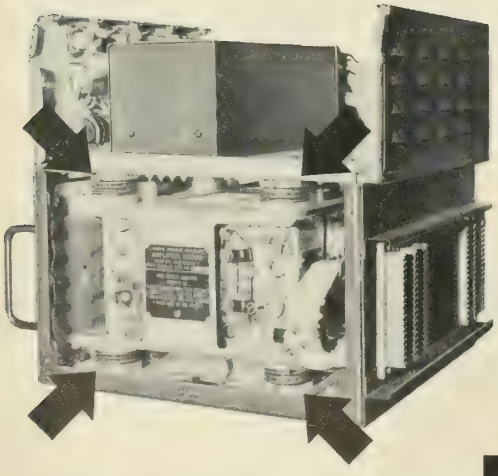
A Case History of Environmental Control

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POWER TUBE FAILURE during environmental testing of the Servo-Amplifier in the flight stabilization system of Chance Vought's F8U-1 Crusader.

SOLUTION



ENGINEERED MOUNTING SYSTEM:

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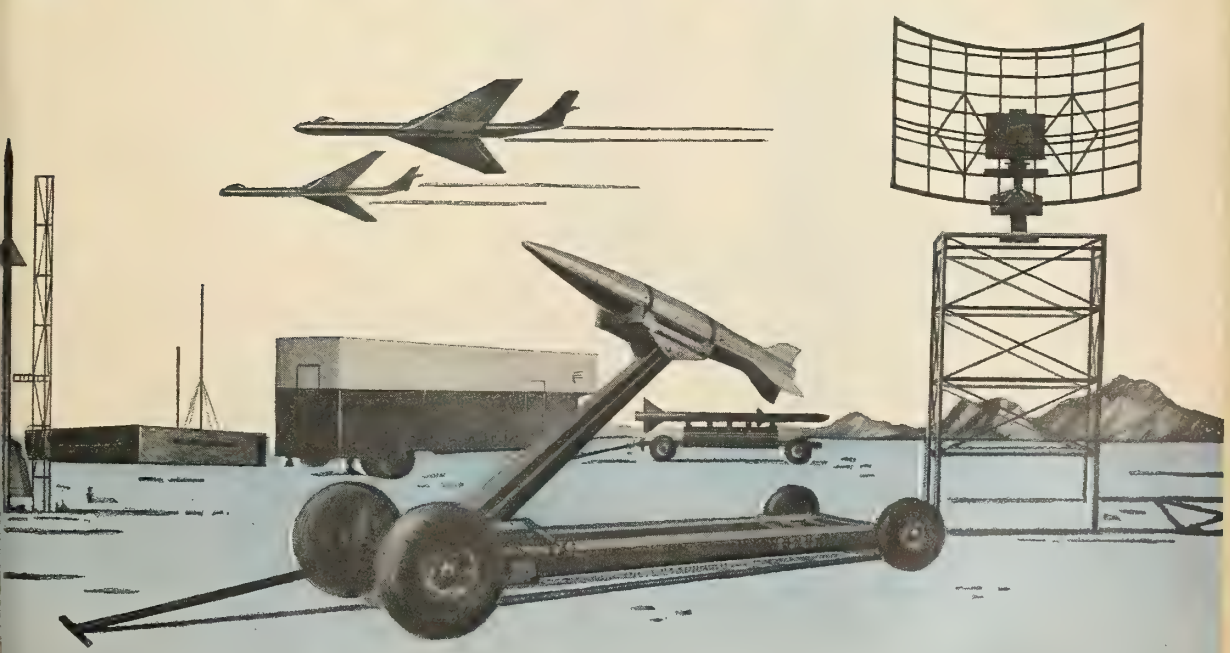
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DECEMBER

ASME Annual Meeting, Hotel Statler, New York, N. Y., Dec. 1-6.

American Rocket Society, Annual Meeting, Hotel Statler, New York, N. Y., Dec. 2-6.

IRE, (Philadelphia Section and Professional Group on Military Electronics) and the Human Factors Society of America on "Human Factors in Systems Engineering," Penn-Sherwood Hotel, Philadelphia, Pa., Dec. 3-4.

High Temperature Strain Gages Symposium, Aeronautical Structures Laboratory, Naval Air Materiel Center, Philadelphia 12, Pa., Dec. 4-5.

ARS Eastern Regional Student Conference, sponsored by the Polytechnic of Brooklyn Chapter, Hotel Statler, New York, N. Y., Dec. 6-7.

IRE, AIEE, ACM, Eastern Joint Computer Conference, Sheraton-Park Hotel, Washington, D. C., Dec. 8-11.

Eastern Joint Computer Conference and Exhibit, Sheraton-Park Hotel, Washington, D. C., Dec. 9-13.

Gas Turbine Development Meeting, Speaker: Rear Adm. S. B. Spangler, USN, Air Development and Materiel Center, Engineers Club, Philadelphia, Pa., Dec. 18.

JANUARY

Electronics Reliability and Quality Control, Fourth National Symposium, Hotel Statler, Washington, D. C., Jan. 6-8.

IAS 26th Annual Meeting, Sheraton-Astor Hotel, New York City, N. Y., Jan. 27-31.

American Astronautical Society, Fourth Annual Meeting, New York City, N. Y., Jan. 29-31.

College-Industry Conference, American Society for Engineering Education, University of Michigan, Ann Arbor, Mich., Jan. 30-31.

Instrument Short Course, sponsored by Southern California Meter Association and Los Angeles Harbor Junior College, Wilmington, Calif., Jan. 30-31.

FEBRUARY

Reinforced Plastics Division Conference, Society of the Plastic Industry, Edgewater Beach Hotel, Chicago, Ill., Feb. 4-6.

MARCH

1958 Nuclear Congress, International Amphitheatre, Chicago, Ill., March 16-22.

ASME Aviation Division Conference, Statler-Hilton Hotel, Dallas, Tex., March 17-21.

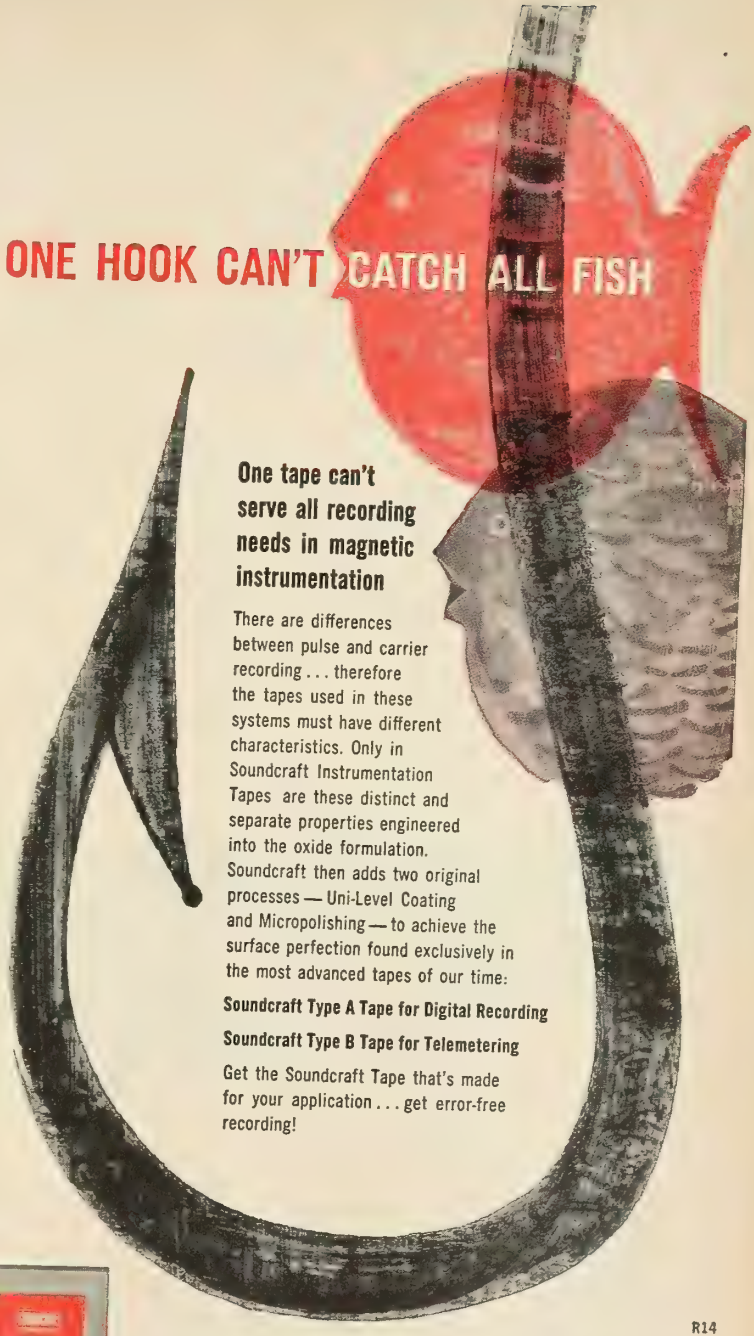
Atomic Industry Trade Show (in conjunction with the 1958 Nuclear Congress) International Amphitheatre, Chicago, Ill., March 17-21.

International Instrument Show, Caxton Hall, Westminster, London, March 24-29.

APRIL

ASME Division of Instruments and Regulators Conference, University of Delaware, Newark, Del., April 1-3.

ASME, Maintenance and Plant Engineering Conference, Penn-Sheraton Hotel, Pittsburgh, Pa., April 14-15.



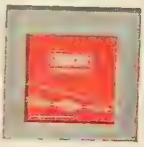
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A REPORT ON THE FIRST SUCCESSFUL PROCESS FOR CHEMICALLY MILLING LIGHT METAL CASTINGS

In high speed jets, rockets, and missiles the price tag on every ounce of excess weight is enormous. Even the use of lightweight aluminum and magnesium alloys wherever possible leaves room for improvement. For while part thickness is often determined by structural requirements, it is frequently a function of the metalworking processes used. Castings, for example, must have sufficient wall thickness to assure sound structure throughout. Thinner sections are generally achieved by machining the parts after casting. This is often an expensive and sometimes impossible task, especially where complex contours or double walls are involved.

Enter Chemical Milling

The first break came when a solution was discovered to the same problem as it affected wrought parts. The solution—familiar to every high school chemistry student—was based on the consumption of metals by powerful reagents. Its successful application to metalworking production presaged significant strides in weight reduction. But when the same techniques were applied to castings, results were extremely poor.

Rolle research immediately began laboratory tests to discover the reason for the failure, and found it often lay *in* the castings. Even minor imperfections in the casting surface unbalanced the process of metal removal—enlarging any defects present. Rolle also found, after much searching, that only certain reagents in certain concentrations—depending on both the part cast and the alloy used—could guarantee success. It has taken almost two years of exhaustive research to refine this process to the extent that it can now take its place as an accepted metalworking technique. Parts can now be designed for casting that could only be constructed by sheet fabrication techniques in the past.

Half The Wall Thickness

The major advantages of this chemical milling process are pretty much wrapped up in the single figure 0.060"—the wall thickness which Rolle can consistently meet by the process. The importance of this figure is readily comprehended by comparing with it the conventional limit on casting wall thickness—.125". Rigid control techniques, developed in the laboratory, even permit an overall improvement in dimensional tolerances of the part as a result of the chemical milling process. And at the same time, surface finishes of an order of 100 microinches or better can be consistently achieved.

There are two ways you can take advantage of this Rolle technique for chemical milling. One requires the controlled removal of metal from the entire surface area of the part. Allowance can be made in the pattern for holding heavy sections and critical dimensions despite chemical metal removal. The other method, useful where the areas to be lightened are relatively limited, requires masking of those areas not to be etched. The proper technique, of course, can only be decided on the basis of the individual part.

Since the success of chemical milling depends to a considerable extent on the soundness of the casting itself, Rolle cannot promise satisfactory results on any but a Rolle cast part. But Rolle will gladly examine your prints and parts in light of this new technique and make recommendations or quote prices, as you desire. Furthermore, we'll be happy to answer any further questions you may have relevant to chemical milling or the sand, permanent mold, shell mold, or investment casting of aluminum or magnesium alloys. Write Rolle Manufacturing Company, 313 Cannon Avenue, Lansdale, Pa., or call ULysses 5-1171.

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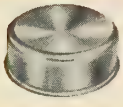
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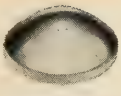
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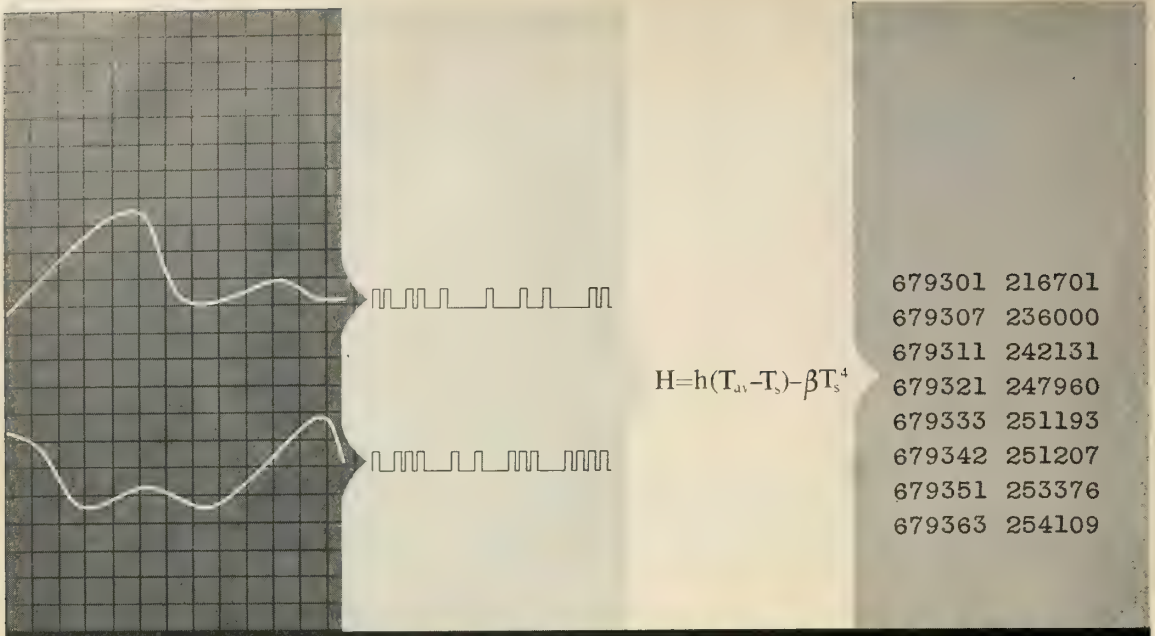


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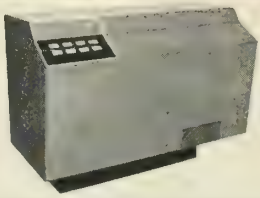
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If your organization has a problem in test control, data conversion, or computation, write to: Director of Marketing, Dept. MR-712, The Ramo-Wooldridge Corporation, 5730 Arbor Vitae St., Los Angeles, Calif.

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Digital techniques employed in the design of the RW-300 computer have also been utilized by R-W systems engineers in the development of special-purpose digital instrumentation systems. Building blocks available for use in such systems include voltage-to-digital converters, electronic commutators, digital data recorders, data-handling links, and special equipment such as the RTD-3103 Range Time Decoder. Additional information on digital instrumentation systems is available on request.

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SOUTHWEST: MARSHALL MORRIS, 3515 Covert Ave., Ft.Worth, Texas, WA.3-8098
NORTHWEST: J. L. LARSEN, 5757 Oaklawn Place, Seattle, Wash., MOhawk 9311
CANADIAN PLANT: THE H.I.THOMPSON CO. OF CANADA LTD., 60 Johnston St. Guelph, Ontario, Telephone: TAylor 2-6630

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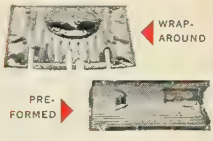
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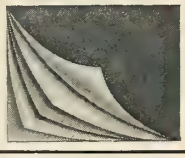
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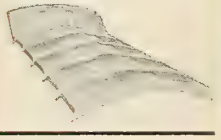
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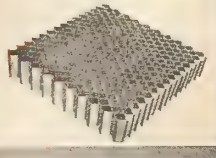
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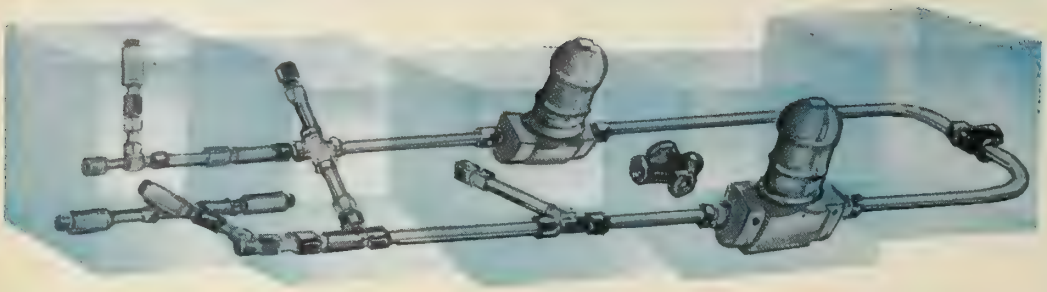
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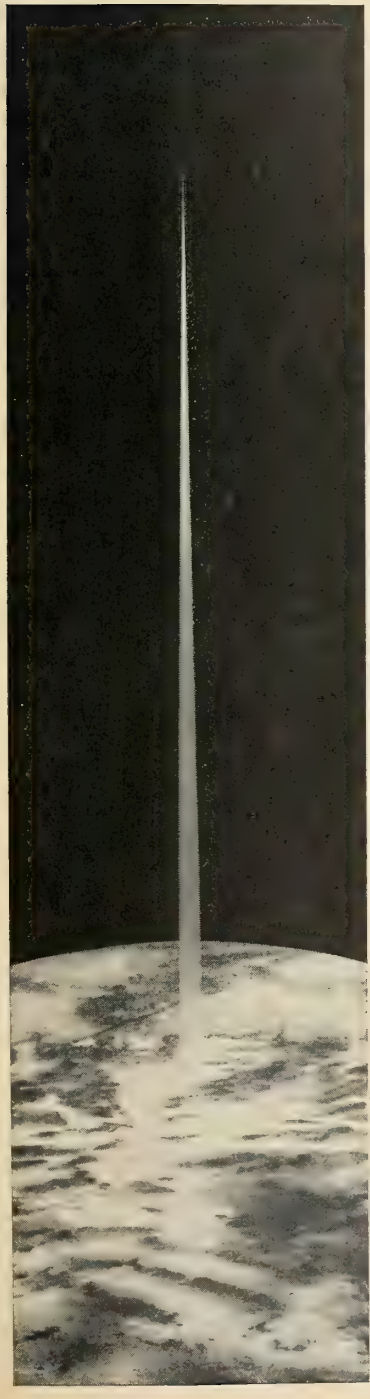
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NORMAN C. REUEL received his BS in Chem. E. at Georgia Tech.. and an MSAE at Cal. Tech. specializing in jet propulsion. Following rocket and radar development in the Navy he joined North American Aviation in 1946 as a research engineer. Now assistant chief of design and development, he also finds time to relax at his ranch home, bowl, golf, and play tournament bridge.



PAUL D. CASTENHOLZ, Pacific combat veteran, graduated B.Sc. (Eng.), UCLA 1949. From research engineer his grasp of rocket engine work raised him through a supervisory post in experimental development to assistant group leader in combustion devices, and then to group leader of experimental engines. Recently completed requirements for his MSc. Relaxes with hi-fi, fishing and back packing.

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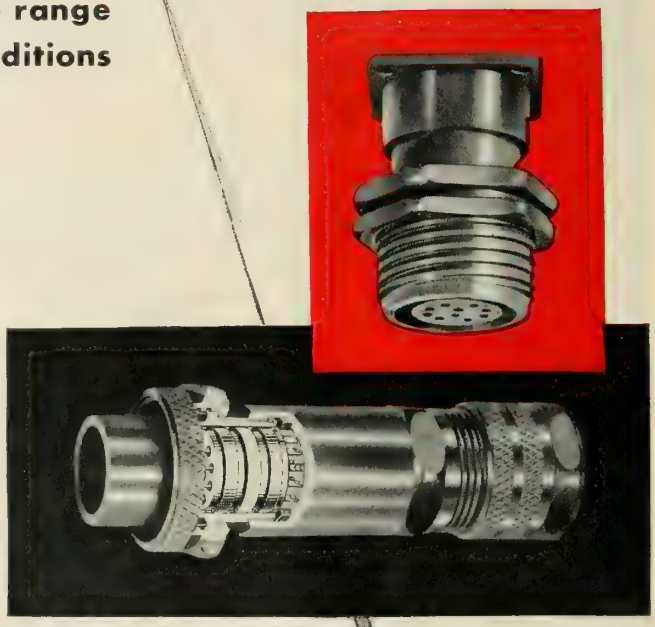
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letters

M/r Commended for Open Letter to President

To the Editor:

The letter, published on the same day as the report of work by Soviet scientists on a "photonnic" drive, focuses attention on the work that must be done by scientists here in the United States if we are to resume our lead.

Your proposal for a Secretary of Science is very interesting, and, if placed above political squabbles, could accomplish a great deal. A Secretary of Science could, for example, if given sufficient power, cut through a great deal of red tape, and decide, as you bring out so aptly, which of our mssiles to develop.

A point which you did not touch on is education of our youngsters. As long as Soviet education stresses the mathematical and physical sciences from elementary school onward, and our educational systems allows a great proportion of our students to get by with the minimum in these sciences, we cannot look forward to a steady and continuous flow of the young scientific talent that we need. Even if we should institute a "crash program," if we do not continue to develop scientific talent, the program will of necessity die down.

The letter is a great service to the public, and a copy should be sent to each Senator and Congressman.

I. A. Rothstein
1891 E. 7th St.
Brooklyn 23, N. Y.

To the Editor:

Bravo! Recommend followup rebuttal to Presidential speech to wake the gullible Gulliver of America. Suggest you ask Americans to mail copy they read to their Congressmen signing it "Me Too."

Schuyler Hamilton
149 East 34th St.
New York, N. Y.

To the Editor:

I was deeply impressed . . . I know the letter has wakened many complacent Americans to a new sense of urgency in advancing our knowledge in the satellite, rocket, and missile fields. For this great service to your country, I heartily congratulate you.

Robert Troy
660 Gibson Ave.
Kingston, Pa.

Congratulations. Magnificent. I fervently hope it gets results and soon.

Carl Friedlander
983 Park Avenue
New York City, N. Y.

To the Editor:

You are to be commended for your views in this matter of most important concern to the U.S.

Harold Moy
71 West 71st St.
New York 23, N. Y.

To the Editor:

It certainly puts the Sputnik-Eisenhower problem in its proper perspective. Congratulations!

James B. Kobak
J. K. Lasser & Co.
1440 Broadway
New York 18, N. Y.

To the Editor:

Congratulations. Constructive criticism most timely. Lethargy and penny-pinching in scentific fields totally indefensible. We could easily become the Communists' richest satellite.

Dena Connery
7714 East Jefferson
Detroit, Mich.

To the Editor:

I can find but one word . . . "Terrific."

Frank C. Beckert
Howard A. Harkavy, Inc.
341 Madison Ave.
New York 17, N. Y.

To the Editor:

I am in complete agreement.

I have taken the liberty to quote you in a letter to Senator Kefauver.

John W. Whitson
120 Cabrini Blvd.
New York, N. Y.

To the Editor:

. . . a distinct public service . . .

Murray W. Greif
Petroleum Solvents Corp.
331 Madison Avenue
New York 17, New York

Details Wanted

To the Editor:

I would like further details on rocket sleds and rocket propulsion systems . . . as reported in m/r, March 1957.

H. Paddon
2528 Jay Place
Colorado Springs, Colorado

He Should Know

To the Editor:

Our heartiest congratulations. Your open letter to the President . . . was read in full by Bob Sigrist of Station WENR in Chicago. I fervently trust and hope the President will give your letter full consideration. I am sure that you are being instrumental in formulating our future missile and space policy.

Joe Kauffman, President
Diversey Engineering Co.
Chicago, Illinois

Wants Encyclopedia On Guided Missiles

To the Editor:

Your magazine is excellent and far above any other magazine in this field. I read in your August issue you had reprints of your excellent First Annual Guided Missile Encyclopedia. I would like a reprint.

Allan Gary
317 Shadowmoor Dr.
Decator, Ga.

In the mail.—Ed.

To the Editor:

We enjoyed the information in the Guided Missile Encyclopedia. Since a considerable amount of our interest is in the missile field, I would appreciate it if we could obtain five reprints for distribution to our key personnel.

Dr. Lawrence Gould
Microwave Associates, Inc.
Burlington, Mass.

In the mail.—Ed.

Second in a series,
"Earliest History of Aeronautics"



GENIUS
in the
AGE OF SPECULATION
Leonardo da Vinci, 1452-1519

The contributions to the advancement of early aeronautics made by Leonardo da Vinci were indeed tremendous. With his studies, notes, sketches and experiments he was considerably more than a mere speculator during the "Age of Speculation" in aeronautical history.

Leonardo was the first successful inventor of aerial craft of any kind—the helicopter. His flying models employed a rotating fan, or aerial screw, which became the forerunner of all propeller driven transportation, both aerial and marine.

In 1514, his sketches and aerodynamic notes described a "fall-breaker"—this led to the first successful parachute.

The ornithopter was Leonardo's greatest dream of human flight, but his theory that man could flap bird-like wings and lift himself was unsuccessful. His famous notes and sketches misled many later generations of wing-flapping aerial experimenters, but much credit is given him for keeping the spirit alive in men who sought to conquer the air.

Age of Speculation, 20th Century

Today's study of missiles, satellites and space travel finds us in a new "Age of Speculation." Helping to convert theory into reality is Aerotest Laboratories, the country's leading single source of testing services for the aircraft and missile industry. Aerotest performs complete functional and environmental testing in accordance with all military and commercial specifications.

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Beg Pardon

To the Editor:

On receiving my August issue of m/r I was surprised to note on page 84 (under the author's name) that the Jet Propulsion Laboratory was reported located at Huntsville, Ala. We would greatly appreciate a statement in your next issue pointing out that the address should have been Pasadena, Calif. In reality, JPL is affiliated with the California Institute of Technology rather than Redstone Arsenal or the Army Ballistic Missile Agency, although we frequently work closely with these groups on certain programs.

John I. Shafer
Staff Engineer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena 3, California

Additional Kudos

To the Editor:

I have been reading m/r since its inception, and truthfully state, I have never before encountered so informative a trade publication. To me it is a warehouse of accurate and authentic information. It's content shows a profound editorial insight, rarely, if ever found in a trade journal.

I eagerly await each issue and in view of current federal negotiations, trust it will become the unchallenged bible of the trade.

Frank J. Cunningham
142 Bellmore Road
East Meadow, N.Y.

Information Requested

To the Editor:

A friend and I are planning an exhibit on solid fuel rocket engines for the science fair in our area. I have obtained some information on this subject, but not enough. Could you refer me to any books or magazine articles where I might find something on this subject?

Gaylon Campbell
585 West Fourth North
Logan, Utah

We will forward some details that might be of use to you.—Ed.

To the Editor:

I have been interested in Thorium Ores and Yttrium Oxides and would like to ask of you as to what, if any, part they play in the missiles and rockets.

Danny Bogni
250 Columbus Avenue
Daytona Beach, Florida

Our propulsion editor has an answer for you in the mail.—Ed.

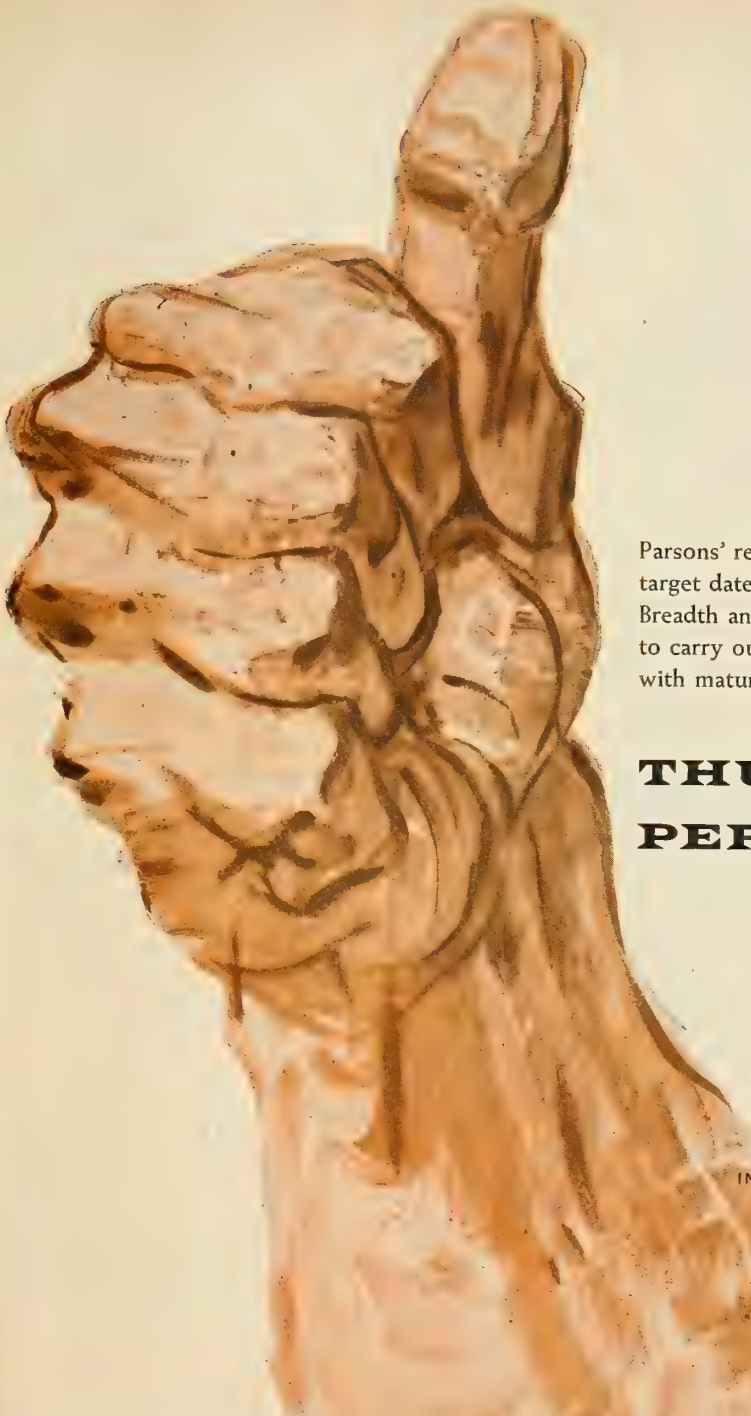
Missile Glossary Needed

To the Editor:

We are frequently asked by students of junior and senior high school grade for a hard and fast explanation of a rocket and a missile. Our impression is that the two words are used more or less interchangeably now, but we ask your advice so that we can pass out authentic explanatory information.

It would help us to know the difference between a rocket and a missile, and between a ballistic missile and manned and unmanned rockets and missiles, space ships, and guided and unguided missiles and rockets. As a matter of fact, probably a glossary of these space age terms

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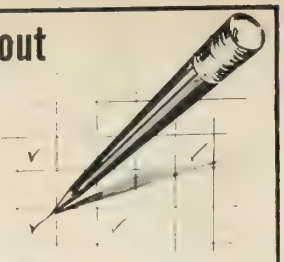
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Shelves completely or partially
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allows tandem towing.

TOWABILITY
Rings afford tie down
and hoisting provision

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casters; Lock and break mechanism.

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Skydyne's aluminum faced sandwich construction benches provide versatile, compact, mobile units to facilitate on sight checkout of electronic systems or components of rockets and missiles. Specially engineered and designed to your requirements in size and layout or existing designs adapted to your needs. Skydyne's experience and guarantee saves you time, money and responsibility.

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Circle No. 19 on Subscriber Service Card.

might be well to publish in one of your editions and in that way many other public relations people besides ourselves could become readily acquainted with the precise definition of each term.

From the very name of your publication we assume that there is a distinction and a marked one between a missile and a rocket. Where we become confused is when the terms are used together; for instance, as a missile which is fired into space by means of rockets.

Are we correct, for instance, in saying that a ballistic missile could be an H-bomb located in the nose of a two or three stage rocket and that when it reaches outer space the missile orbits by itself, divorced from the rockets which shot it there? Would it then correctly be termed an orbital ballistic missile, etc.?

Ballistics is said to be the study of the motion of projectiles; a missile is defined in some encyclopedias as something which can be thrown into space; and a rocket is defined as something which is fired under its own power.

More definitive information about all this would certainly be appreciated.

Arthur F. Joy
Public Relations Department
Raytheon Manufacturing Co.
Waltham 54, Mass.

A glossary of missiles, rockets, and space age terms is planned for the near future.—Ed.

Von Braun Reprints

To the Editor:

You have undoubtedly established your magazine as the leader in its field.

To echo another letter to the editor, you have indeed started something in granting m/r cover reprints. I, too, want a color reprint of the July cover of the Bell X-1E. I would also like reprints of Dr. Wernher von Braun's article, "Space Travel and Our Technological Revolution" and the very excellent article by Joseph G. Logan, "New Air for Engineers."

William R. Elliott
3367 Pio Nono Circle
Macon, Ga.

In the mail.—Ed.

To the Editor:

Add my congratulations for your excellent magazine to your growing list. It has filled a great need very admirably.

I would like a copy of Dr. von Braun's "Space Travel and our Technological Revolution." Also a copy of the Guided Missile Encyclopedia, both published in your July 1957 issue. As a recent subscriber, I missed this issue but discovered these articles through my colleagues and our engineering library at Minneapolis-Honeywell's Aero Division.

Reinhold V. Gaertner
5724 West Moore Lake Dr.
Minneapolis 21, Minn.

To the Editor:

I read with deep satisfaction "Space Travel and Our Technological Revolution" by Dr. Wernher von Braun in your July issue. I would appreciate a copy of the special reprint of this article.

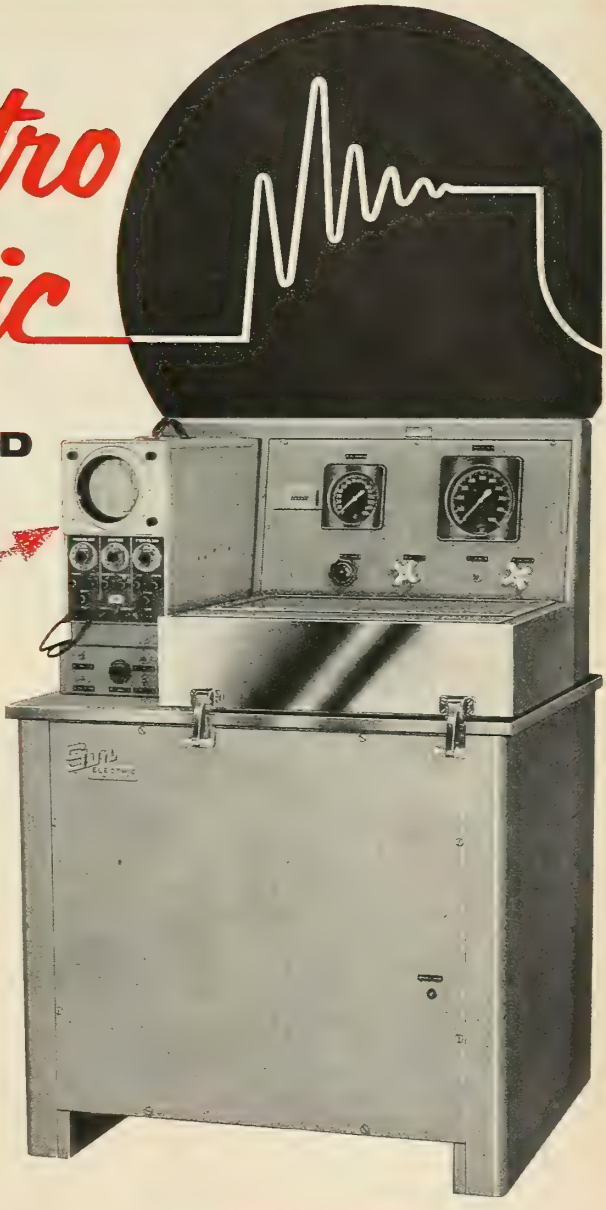
May I also take this opportunity to congratulate the entire staff of m/r for the excellence of your publication and especially on the First Annual Engineering Progress issue. It was by far the most comprehensive, informative compilation of such data ever assembled. Keep up

AGAIN - - - FIRST WITH THE FINEST

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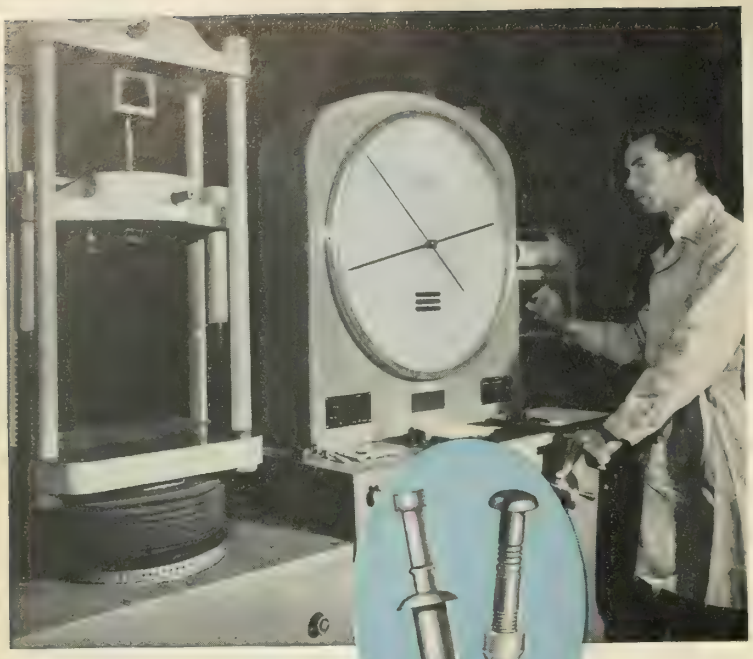
SPECIFICATIONS
Model SX-89 Impulse Test Stand

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In the mail.—Ed.

Missile Machine Companies

To the Editor:

In the article on "Machining for Missiles," m/r September 1957, was mentioned that, including Diversey Engineering Co., there are some 16 missile machining companies in the country. It is requested that this Arsenal be furnished with a list of names, addresses and resume of work in and facilities for missile machining of these 16 companies.

A. Friedman
Contracting Officer

Ordnance Corps
Picatinny Arsenal
Dover, New Jersey

This list is in the mail.—Ed.

Reporting IAF Congress

To the Editor:

. . . your article on the last International Astronautical Federation Conference and your editorial "Washington Trends." I want to compliment you on a very complete reporting of the conference and a complete factual editorial highlighting many of the current problems we now face in the missile field.

Bill Timm

1920 Home Ave.
Bronx, N. Y.

Amateur Facilities

To the Editor:

I know of several teenagers here in the East with serious interests in rocketry, myself included, who would like to fire their own rockets. Unfortunately, being teenagers we cannot drive out to the Mojave Desert every time that we want to hold a firing because of the distance involved. Because of this I would like anyone with serious ideas on the subject to write to me.

I would like reprints of Dr. Wernher von Braun's excellent article, "Space Travel and Our Technological Revolution," the Guided Missile Encyclopedia and your beautiful June cover.

Frank Dishaw

1040 N. Ray Ex.
Manchester, N. H.

How About Inventors?

To the Editor:

What part do you expect the American Inventor to play in the new rocket & missile program?

Do you believe you can get the government or industry to accept the man that MADE the thing and who has something new and practical to offer?

In the past it has been: don't let any new ideas in, and if they do get in, don't pay for them and be sure that the inventor is not around to help or get paid.

George E. Barnhart

2228 New York Drive
Altadena, California.

Circle No. 21 on Subscriber Service Card.

German Rocketeers in US/USSR

To the Editor:

For the last two and a half years, I have been collecting detailed information, technical as well as nontechnical, about guided missiles, rockets and its allied subjects. I immensely appreciated Mr. Parrish's foresight, when he started "Missiles & Rockets" last October, although I think starting of this magazine a bit earlier would have greatly increased the tempo of U.S. progress in these fields.

The growing challenge posed by Russia, demonstrated recently by their ability to launch two earth satellites, has brought these obscure subjects to the front pages. It is not my intention to go into the political aspects of the situation; but the very fact that USSR has been able to master these difficult technical fields in relatively short time, shows beyond doubt that they have availed of to their fullest use the talents of the best German wartime rocket experts.

I have for sometime been collecting the names of German rocket and missile scientists working both in USSR and USA but due to very scarce information that is available in newspapers and other magazines, I have not gone far. I'm therefore, writing this letter in the hope that you will be able to give me in detail the names of top German, Russian and American rocket scientists working in USA and USSR mentioning the fields in which they have specialised.

Krishnanand M. Amladi
43-B Irwin Road
New Delhi-India

Check our next "Russian issue"—Ed.

What's the Story on ASMs?

To the Editor:

First, I would like to express our appreciation for the copies of your Guided Missile Encyclopedia that you sent us. We have subscribed to m/r since its founding and have thoroughly enjoyed each and every issue. We have recently directed our attention to the air-to-surface missile field and wonder if you could either briefly bring us up to date on further developments in that field (subsequent to your Guided Missile Encyclopedia), or direct us to some other source.

T. W. Merritt, Jr.
Chicago Title and Trust Co.
111 W. Washington St.
Chicago 2, Ill.

U.S. does not have much of a sophisticated program in this field. Other than Bell's RASCAL *and the new North American ASM, we don't know of any new developments.—Ed.*

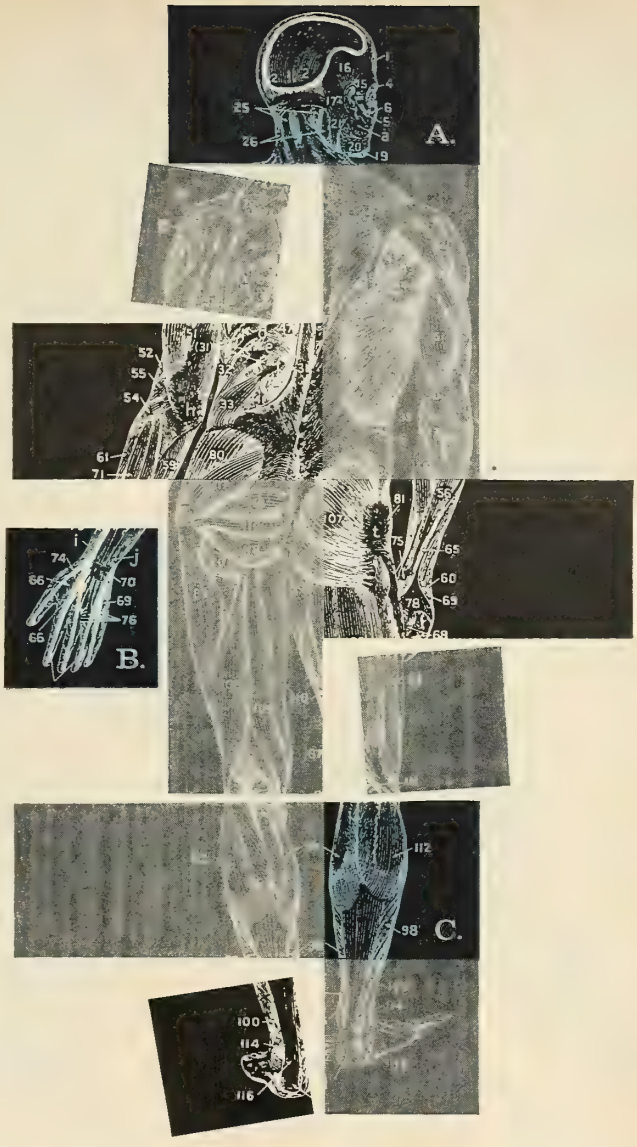
Geschutenverbe Werdebake

To the Editor:

I am a new subscriber and find your publication beyond what I had expected. It is the most comprehensive I've seen. I am employed at the Oak Ridge National Laboratory and some of my friends and I were delighted with the "Geschutenverbe Werdebake" in the September issue (p. 54). I see that Durant mentioned it again in his column, "World Astronautics." I would appreciate a copy very much. Also, can you tell me the address of the Deutsches Arbeitsgemeinchaft für Raketentechnik (DAFRA)?

Henry Phillips II
P.O. Box 974
Oak Ridge, Tennessee

Your letter has been forwarded to Durant; he will answer you within the next few days.—Ed.



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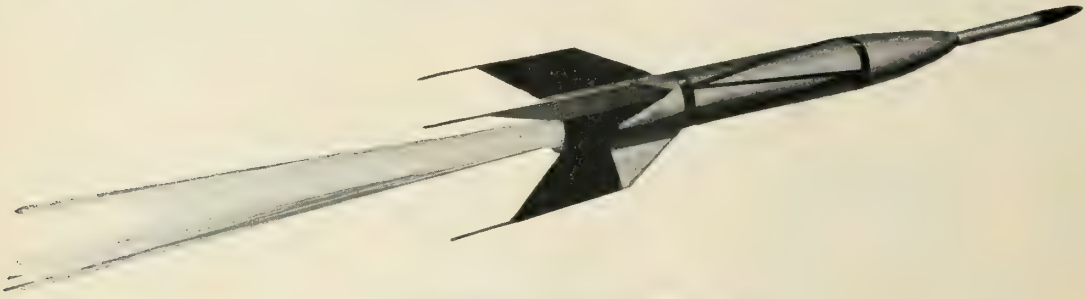
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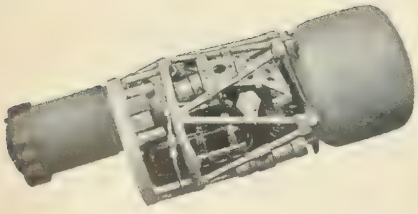


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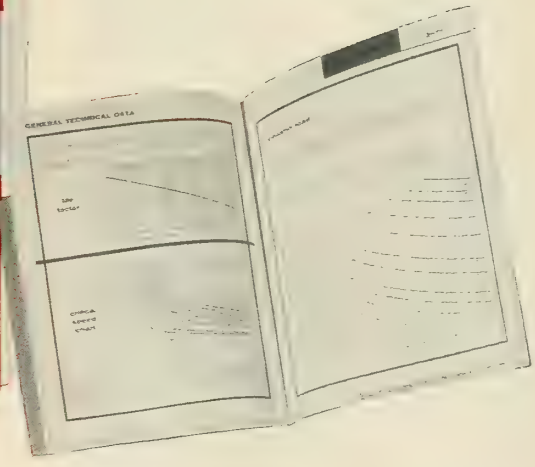
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Soviet Troops Get New Missiles

Present Red Operational Stockpile Twice as Large as U.S. Arsenal

by Frank G. McGuire

The Soviet Army paraded its missile muscles through Red Square recently and left little doubt that considerable technology backed up the mass of hardware shown. Although exhibiting little but tactical missiles, the Soviets answered any questions that existed about the variety or modernity of their missile arsenal.

The mobility of the missiles was in sharp contrast to the horse-drawn-cart days of World War II, and many of the models obviously fulfill the same missions as American counterparts—even to being quite similar in design. The largest missile shown was the T-1, which one magazine erroneously labeled the IRBM T-2. This T-1 was apparently the "80-foot monster" referred to in preparade press reports from the Soviet capital, although its actual length is much closer to 60 feet.

Design characteristics of the T-1 indicate that it uses a LOX system and is generally similar to the *Redstone*. The T-1 is undoubtedly vertically-launched and is equipped with four small fins for stability. Graphite vanes projecting into the exhaust stream indicate that the Soviets have not made use of the gimballed-motor technique. Range of the T-1, with its 77,000-pound-thrust engine, is about 400 to 600 miles.

Judging by the appearance of large-caliber rocket-launching guns, the Soviets have effectively rendered our atomic cannons obsolete. The atomic cannon, with its 20-mile range, is no match at all for the estimated 120-mile range of these tank-mounted guns. The rocket guns have 70-foot barrels, very small recoil mechanisms, and generally follow the Rheinbote design. The short crane, contrasted with a large missile carrier on one gun chassis, seems to indicate that the missile is loaded in stages. Another model utilized a larger crane, suggesting that a single-stage, solid-fueled rocket is used. As far as is known, there are no American designs of this large size following the Rheinbote idea, but several American companies (Aerojet and Armour) are working on smaller models.

Another impressive missile shown was the T-7A, a solid-propellant rocket with a range of about 25 to 30 miles. The weapon is 25 feet long, about three feet in diameter and is carried into battle on a tank. It is launched vertically.

The large size and weight of the missile, in addition to the clean lines and single motor, hint that the Soviets have mastered the manufacture of large composite grains. The design is distinctively Soviet and seems to incorporate greater punch and mobility than either our *Corporal* or *Sergeant* missiles. It could be submarine-launched without too much modification and may be a prototype model of the *Comet*.

Soviet Missiles

Model	Range (miles)	Length (feet)	Diam.	Mission	Thrust (pounds)	Power Plant	Status	Remarks
M 100A	5	7	10″	AAM	n.a.	n.a.	Operational	Standard USSR air-to-air weapon
T-8	20	n.a.	n.a.	SAM	n.a.	SPR	Operational	In use for several years. Other rockets in this category are the T-6 and the GVAI
M-2	20	25	3′	SAM	n.a.	n.a.	Operational	Similar to ***Nike-Ajax***, but larger
T-5B	25	30	2-3′	SSM	n.a.	n.a.	Operational	Free-flight artillery rocket, much like U.S. ***Honest John***
T-7A	50	25	2.5′	SRBM	17,600	SPR	Operational	Truck-launched
Comet III	100	15	n.a.	ASM	n.a.	SPR	Operational	Radar guided
Comet I	100	n.a.	n.a.	SRBM	n.a.	SPR	Production	May be launched from submarines against land targets
Comet II	600	n.a.	n.a.	MRBM	n.a.	SPR	Production	Same as **Comet** I, above
T-1	400-600	50	5.5′	MRBM	77,000	LPR	Operational	Improved version of German V-2
T-4	1,000	50	5.5′	IRBM	77,000	LPR	Production	Version of T-1, uses wings to glide to target after burnout
T-2	1,800	100	15	IRBM	254,000 77,000	LPR(2)	Operational	Many test flights reported
T-3	5,000	125	n.a.	ICBM	n.a.	LPR	Final Test	Test flights conducted by Red Army
T-4A	12,000	n.a.	n.a.	Skip-Glide Bomber	820,000	LPR	Flight Test	Manned rocket bomber capable of operating at altitudes to 160 miles

n.a., not available; SPR, solid-propellant rocket; LPR, liquid-propellant rocket; AAM, air-to-air missile; SAM, surface-to-air missile; SSM, surface-to-surface missile; ASM, air-to-surface missile; SRBM, short-range ballistic missile; MRBM, medium-range ballistic missile; IRBM, intermediate-range ballistic missile.

A Martin Matador, big as a jet fighter, thunders into the air leaving a blazing trail as it roars toward its 40,000-foot operating altitude.

Safeway

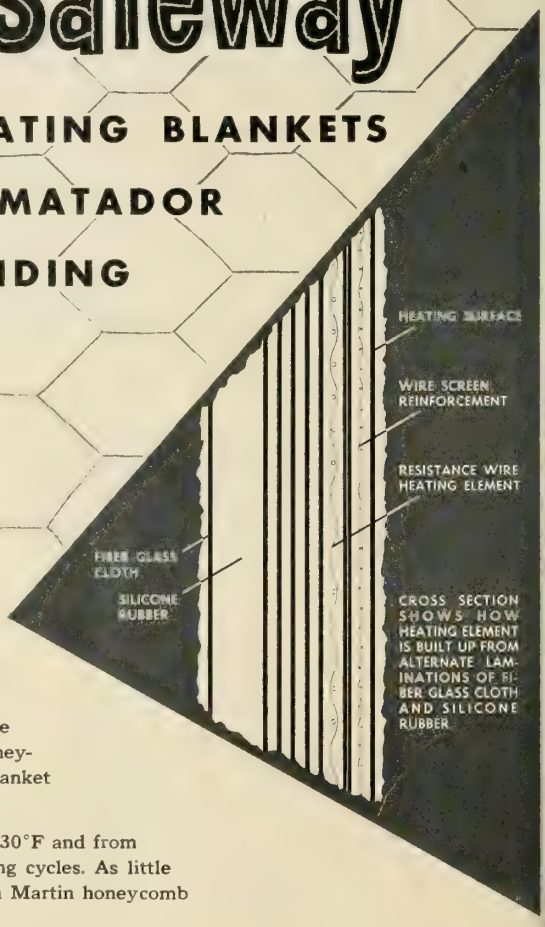
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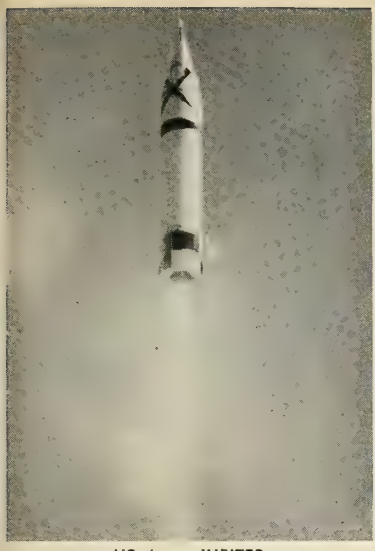


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Showing some similarity to our *Nike-Ajax* the Soviet M-2 is transportable and launchable from its truck-trailer. It is an AAM, probably an offshoot of the M-1, with shipboard AA defense capabilities. The M-2 does not require a fixed position from which to fire, as does our *Nike* series and may move with battlelines for use in combatting enemy aerial strikes and air reconnaissance. It is considerably larger than our *Nike-Hercules* and *Terrier* missiles and is a trim, two-staged rocket with several areodynamic control surfaces. The large booster-nozzle shows high thrust while the smaller second-stage nozzle indicates a long burning time. It undoubtedly has a range of about 40 miles, altitude capability of 60,000 feet, and is capable of combatting our B-47 and B-52 bombers. Although supporting guidance and control equipment was not seen, the nature of the rocket indicates that the electronic equipment is very probably on a par with ours.

Another new rocket displayed was the T-5B, which bears a striking resemblance to our *Honest John*. It has a similar-size warhead, but the solid-propellant motor is considerably necked down, giving a thin-waisted appearance. The booster motor features 6 canted nozzles.

The powerplant is in two stages, but the small rocket motor and large warhead indicate a support weapon with about a 15-mile range. A considerable number of small artillery rockets for infantry support and flak against low-flying aircraft were also shown in the parade.

The purpose of the show could well have been to impress on the NATO countries that Europe will indeed be swept by an avalanche of Soviet troops should war break out. Their missile mobility and flexibility is undoubtedly aimed at swaying the neutral countries in their determination to remain that way. The overall effect of the parade was to eliminate any doubts that the Soviet Union can handle small wars as well as an all-out effort.

As can be seen from the comparison charts, the Soviets have checkmated the U.S. in all areas of missiles, and in at least two cases (skip bombers and ballistic missile between 250 and 1500 miles range), we have nothing at all. Their infantry support weapons, anti-tank missiles and low-altitude antiaircraft missiles outnumber ours in types and undoubtedly in numbers. However, the figure of 20,000 operational missiles recently quoted for the Soviet IRBM is exaggerated.



USAF THOR
. . . big missile-maker Douglas is ready

The Soviet missiles seem to be supported by more mobile ground support equipment than their U.S. counterparts. A large number of the vehicles attendant to the missiles were tracked for greater cross-country mobility and provisions were made for protection of the crews.

Although there have been claims that Soviet missiles are crude, as is always the claim from this side of the fence, there is little doubt that they are practical, effective and operational. Many of ours are not.

United States Missiles

Model	Range (Miles)	Length (Feet)	Diam.	Mission	Thrust (Pounds)	Power Plant	Status	Remarks
Falcon	5	6.5	20″	AAM	6000	SPR	Operational	Two models—radar or infrared guidance. U.S. also has ***Sidewinder***
Hawk	15	16.3	14′	SAM	n.a.	SPR	Operational	In use since 1957
Nike-Ajax	20	20	1″	SAM	n.a.	LPR	Operational	Being replaced by ***Nike-Hercules***
Honest John	30	27	2.5′	SSM	n.a.	SPR	Operational	Reliable weapon
Redstone	250	69	6′	SRBM	75,000	LPR	Operational Production	Only U.S. SRBM in operation
Rascal	100	35	4.5′	ASM	6000 each	LPR (3)	Production	In operation soon
Corporal	75	40	2.5′	SRBM	n.a.	SPR	Obsolescent	Has been valuable for troop training
Regulus I	600	33	9.5′	SSM	4600	Turbojet	Operational	To be replaced by ***Regulus II***
Polaris	1500	40-50	8.5′	IRBM	n.a.	SPR	Early Development	Launchable from submerged submarines; ready in five years
				U.S. has no ballistic missiles with range between 250 and 1500 miles.				
Jupiter	1500	58	8′9″	IRBM	135,000	LPR	Flight Test	Air Force's ***Thor*** is similar
Atlas	5000	80	9′	ICBM	(1)100,000 (2)135,000	LPR(1) Boosters	Flight Test	U. S. also pushing ***Titan***
No hardware	10,000	n.a.	n.a.	Skip-Glide Bomber	n.a.	LPR	Study Contracts Only	Many U.S. companies willing to tackle this task



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U.S. Interim Underwater Missile Platform?

A worthy design approach for fleet ballistic missile warfare, which may be receiving top level consideration in light of recent disclosures of Soviet missile submarine might, has been proposed by the Wilford Aircraft Corp. of Merion Station, Pa. The proposal aims to put our fleet in a position of readiness in the shortest possible time. The missile carriers would use available submarine hardware until a substantial fleet of missile-launching submarines has been completed.

Although several broad configurations appear feasible, a design utilizing available submarine hardware as ballistic missile and aircraft carriers is the most promising from the standpoint of time and money. Two World War II type submarines would be lashed together with a detachable hanger-launching pod between them (see drawing). This catamaran-type vessel would be capable of great endurance on the surface or subsurface while carrying fuel, cargo and missiles with complete operational equipment.

Several *Polaris*-type missiles could be carried in a horizontal position inside the hangar. Two launching hatches are shown in the drawing where the missiles could be fired either from the surface or subsurface. Aft opening is hangar door for seaplanes. The hangar door, when open, becomes a landing ramp for bringing the aircraft aboard.

In addition to the ballistic missiles, several other types could be carried by the catamaran submarine, including air-breathing surface-to-surface, surface-to-air and subsurface-to-air. Wilford further emphasizes that the vessel would be ideal for launching manned vertical or near-vertical takeoff aircraft.

The immediate need for missile-launching submarines (the present development schedule indicates that a sizeable missile submarine fleet is years away), was recently voiced by Adm. H. G. Rickover.

"The nuclear-propelled submarine capable of launching intermediate-range ballistic missiles with nuclear warheads could make our Navy an even more effective deterrent force.

"There is no reason why intermediate-range ballistic missiles cannot be launched from floating platforms, surfaced or submerged. The Navy is, in fact, now developing such a missile, the *Polaris*.

"Armed with this missile, the nuclear-powered submarine will become an underwater satellite. It will be large enough to store, maintain and fire intermediate-range ballistic missiles, and it will be able to move anywhere at any time, completely submerged.

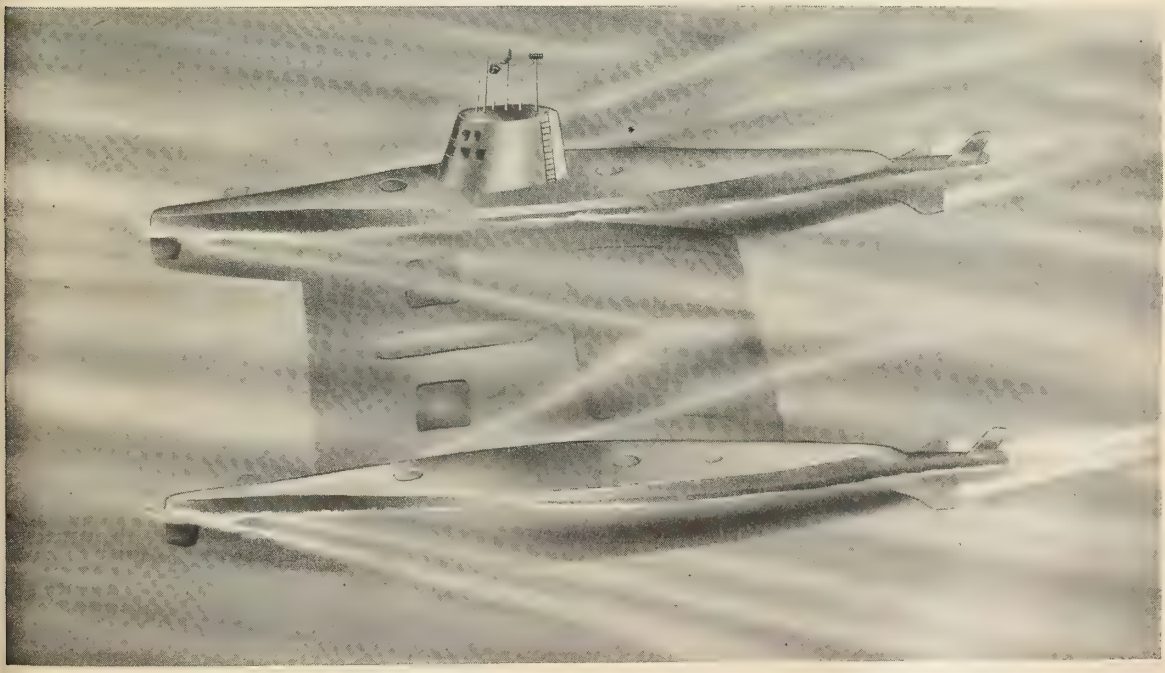
"These underwater satellites will launch their attack from far out at sea. They could be placed anywhere within 1500 miles of their targets.

"The problem of locating and destroying such an underseas fleet will be tremendous. Search radar will be helpless against it.

"The underwater satellite marks the closest approach now foreseeable to the ideal mobile platform. It could remain well hidden from the enemy. It would draw the enemy's missile and bombs away from our cities and factories and farms, and draw them toward the uninhabited seas. An aggressor could not escape destruction as long as this missile fleet remained intact. He would be forced to attack it, thus greatly reducing the number of missiles available to him for hitting our territory or that of our allies."

The true significance of the Wilford proposal for utilizing available, soon to become obsolete, submarines was emphasized by Rickover's remarks regarding development time for this entirely new missile system.

"I should make it plain that this weapon cannot be built by the day after tomorrow. It will be a scientific and engineering challenge, comparable in difficulty and magnitude to the first nuclear submarine."



The Wilford proposal would put our underwater ballistic missile fleet in a position of readiness while awaiting completion of nuclear fleet.



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Soviet Space Agency Revealed

The bold accomplishment of satellite flight by the USSR did not spring from short-term intensive effort. Nor was it dependent on scientific breakthroughs, superfuels and metals or new sources of power. The Russian achievements were the product of a coordinated program, planned by a group of competent scientists comprising the Commission on Astronautics of the Academy of Sciences.

This body had the responsibility of organizing the program, assigning the appropriate research tasks and seeing that this work was carried out. Their job was to identify the basic problems which had to be answered before scientific research satellites could be launched and to obtain the answers. They were eminently successful.

These men were not engineers. The tasks of design, production, logistics and launching were left to the military. The controlling body, however, was the Commission on Astronautics.

Vast Science Organization

The Soviet Academy of Sciences is an elite organization composed of hundreds of scientists assisted by practical experts and technicians. Membership to the Academy brings a special stipend and great professional prestige. In essence it is the centralized body of control of all Soviet science. The interests of the Academy range from pure science through engine design to medieval history. In 1952 it had 40 commissions and committees, 14 museums, 4 observatories, 57 institutes, 38 research stations and 15 laboratories. Through these and other agencies it directs the work of thousands of scientists and technicians throughout the Soviet Union. Policy and direction flows from the Council of Ministers through the Chief Scientific Secretary, appointed by the Communist party. The current secretary is A. V. Topchiev. The president of the Academy is a respected organic chemist, A. N. Nesmeyanov.

Because Russian science is under state domination, heavyhanded, unenlightened administration might easily stifle progress and creative talent. Evidence during at least the last few years, however, indicates that great care has been taken not to demand practical results too quickly but rather to assign requirements, responsibility and authority and let the scientists run the show.

The Commission on Astronautics was officially established early in 1955 under the Academy's Astronomical Council. Its official title is the Interdepartmental Commission for the Coordination and Control of Scientific-Theoretical Work in the Field of Organization and Accomplishment of Interplanetary Communication of the Astronomical Council of the Academy of Sciences of the USSR. The fundamental task of the Commission is ". . . to assist in every way the development of scientific-theoretical and practical work in the Soviet Union concerning questions of studying cosmic space and the accomplishment of astronautics."

Responsibilities Spelled Out

The responsibilities and powers of the Astronautics Commission are specific and extensive. The Commission is charged with:

1) "Taking actions which secure the active participation of academic and branch scientific-research establishments in work for the investigation of cosmic space." (Direct appropriate institutes and laboratories to earmark personnel and time for research on problems assigned by the Commission.)
2) "Organization of work on drawing up problem plans and programs of scientific investigations on the fundamental trends of astronautics." (Draw up a long-range development program and identify the important areas of ignorance to be investigated.)
3) "Broad attraction of scientific-research establishments, of universities and individual investigators to the solution of problems to secure the realization of flight into cosmic space." ("Sell" astronautics as an exciting new field of research to the scientific fraternity.)
4) "Coordination of scientific activities of individual research institutions on the problems of astronautics." (Make certain that there is a "horizontal flow" of appropriate information between the various research institutes.)
5) "Popularization of the tasks and achievements in the field of astronautics." (Educate the population at various levels of intelligence in the technical feasibility of astronautics and



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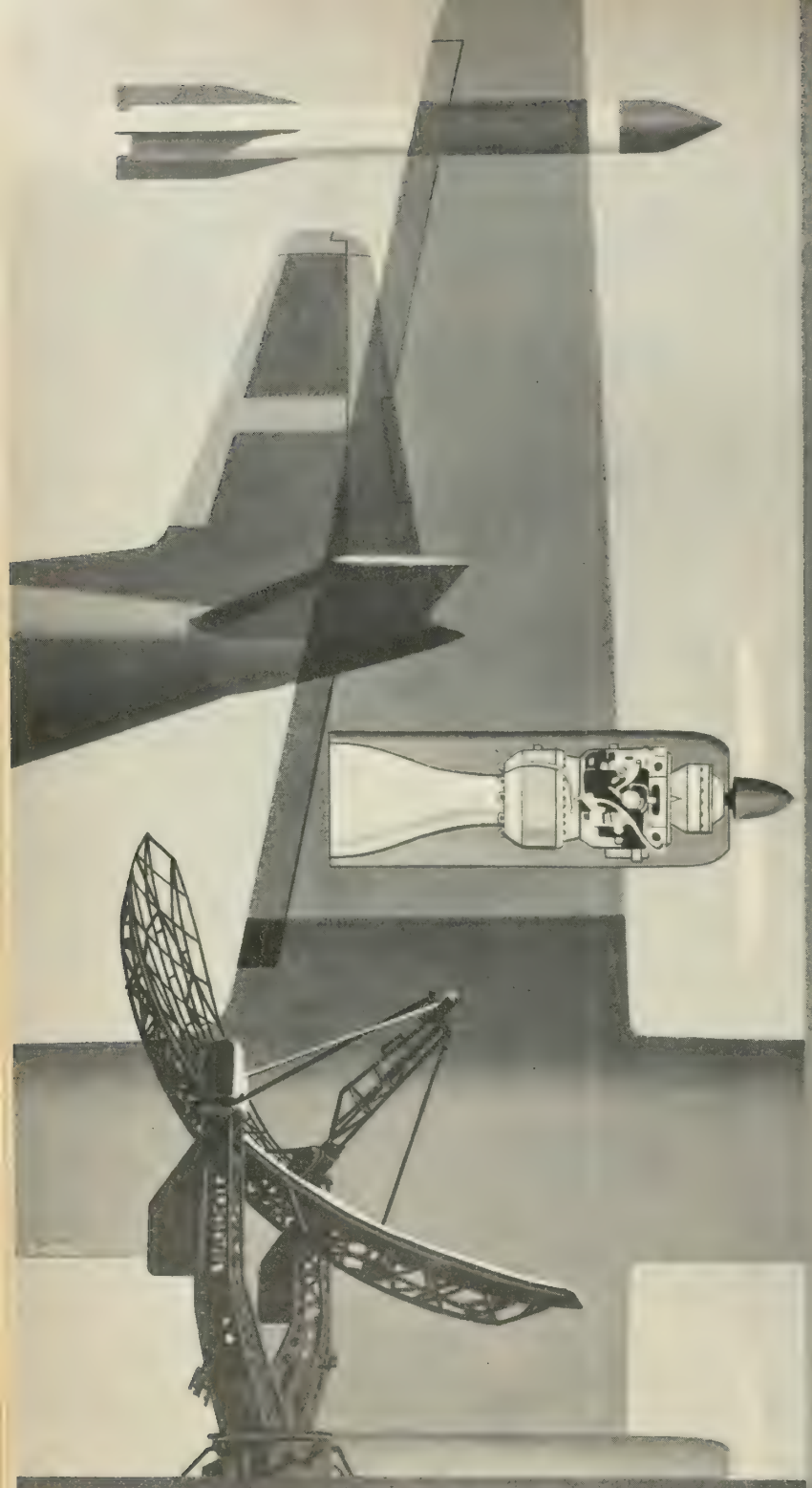
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the potential value of satellite and other space research.)

In addition, the Commission shall:

6) Review the plans and reports of the "scientific research institutes which work on the program controlled by the Commission."
7) Sponsor scientific conferences on astronautical problems.
8) Serve as the award committee in stimulating the submission of scientific work in competition for the triennial K. E. Tsiolkowski Gold Medal, established in 1954.
9) Maintain, through the Foreign Section of the Academy of Sciences, contact with the scientific organizations in foreign countries which are concerned with high-altitude research and space flight.

The Chairman of the Commission on Astronautics is Academician L. I. Sedov. Sedov is a distinguished physicist who has been known for his works in analytical mechanics and gas dynamics.

One important announcement may be forthcoming in the next several weeks—the naming of the first recipient of the Tsiolkowski Gold Medal. This award will be made "to Soviet and foreign scientists for original work of major significance in the development of astronautics." The closing date for this competition was 1 April 1957. It could be expected that the individual (or individuals) named will be those who have played key roles in the development of the first *Sputniks*.

With the successful accomplishment of the initial steps in astronautics the Commission on Astronautics is undoubtedly at work on the more obvious follow-up projects—namely, more and larger satellite vehicles, recoverable satellites, space medical research in satellites, lunar impacting vehicle, and circumlunar vehicles.

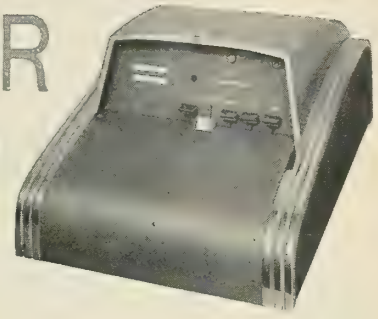
That these projects are technically feasible is no longer a question. The question is, rather, how far along is the USSR in their prosecution. If they are all accomplished in 1958 the United States will really have a hard time catching up. And a still harder time beating the Soviets to later "firsts" in space research.

Academy of Sciences

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number of divisions, each of which has further subdivisions. In each of these subdivisions there is a corresponding institute which is constituted of an expert body of specialists, directing the work of laboratories under its cognizance.

The scientific and engineering activities of each industry are also under the direction of the corresponding institute.

The academy has the following scientific divisions: (1) physics-mathematical, (2) chemical, (3) geological-geographical, (4) biological, (5) technical, (6) historical-philosophical, (7) economical and (8) literary and linguistic.

To illustrate the mass of activities under the divisions, following is a breakdown of the activities of divisions (1) and (5):

Physics-Mathematical Sciences

The division of physics-mathematical sciences consists of:

1) Physical Institute (Moscow)

Atomic fission, cosmic rays, physical optics, spectroscopy, radio physics, propogation of electromagnetic waves, radar, acoustics, theoretical physics.

2) Physical-Technical Institute (Leningrad)

Semiconductors, electronics, polymers, physics of nuclei, properties of solids, dielectrics, synthetic rubber, etc.

3) Institute of Crystallography (Moscow)

Pursues a number of practical problems, for example, the use of different crystals such as dielectrics in oscillating circuits which have special features in selectivity, resonance, etc.

4) Mathematical Institute (Moscow)

5) Institute of Geophysics (Moscow)

Origin of the earth, seismology, earth's electric and magnetic fields, winds, cyclones, tides, ocean currents, etc. The institute has numerous laboratories and stations scattered all over the territory of the USSR.

6) Institute of Seismology (Moscow)

A kind of a subsidiary organization of the Institute of Geophysics.

7) Hydrophysical Laboratory (Moscow)

Another ramification of the Institute of Geophysics; study of ocean currents, winds, spectroscopy of ocean noise, means of reducing ocean waves by means of films of oil, propagation of oceanic disturbances in depth, etc.

8) Astronomical Observatory (Pulpovo)

Observation.

9) Institute of Theoretical Astronomy (Leningrad)

Perturbations, astronomical tables and purely theoretical work in celestial mechanics on the basis of data col-

lected by the Astronomical Observatory.

10) Committee on Meteors
Subsidiary of the Institute of Theoretical Astronomy.
11) Laboratory of Astronomical Instruments
12) Laboratory of Radio-Physics and Radio Technique (Moscow)
Short waves, ultrashort waves, nonlinear oscillations, etc.
13) Spectroscopic Laboratory (Moscow)
14) Acoustical Laboratory (Moscow)
15) Committee on Cosmic Rays (Moscow)
16) Committee on History of Physics-Mathematical Sciences
17) Committee on the Development of Physical Methods in Geophysical Research
18) Committee on Astrophysics
19) Committee on Geodesy
Maps, profiles of the sea, soundings, etc.

Technical Sciences

1) Institute of Energy (Moscow)
Terrestrial electric field, lightning, production of gas, etc.
2) Institute of Fuels
3) Institute of Metallurgy (Moscow)
4) Institute of Mining (Moscow)
5) Institute of Machine Construction (Moscow)
Theory and construction of machines (jointly with the Institute of Metallurgy)
6) Institute of Mechanics (Moscow)
Stability, gyroscopes, dampers, plasticity, shells, aerodynamics, supersonics, propellers, jet, etc.
7) Institute of Automatics and Telemechanics (Moscow)
Control problems (particularly nonlinear ones), autopilots, etc.
8) Committee on Communications (Moscow)
Steam, diesel and electric locomotives, automatic blocking systems for railroads, traffic control, etc.
9) Committee on Waterways
Construction of canals, waterways, etc.
10) Committee on Radio Communications
Use of short and ultrashort waves propagation, taking into account the nature of the earth's surface, presence of iron ores, etc.
11) Committee on Welding and Electrothermal Devices
Welding, study of stresses in structures, etc.
12) Committee on Standardization

This data was prepared by the m/r editors, based on information from Frederick C. Durant III, L. I. Sedov, chairman of the USSR Commission of Astronautics, and William P. Lear.

Reds Reveal Names of Their Space Dogs

The Soviet team of astronautic dog trainers and observers is reported to be headed by Professor Alexis V. Pokrovsky who is helped by at least five assistants, three of whom are men and two are women. The men are A. Seriapin, E. Yuganov and A. Genin. The women are E. Danich and Z. Voronkova.

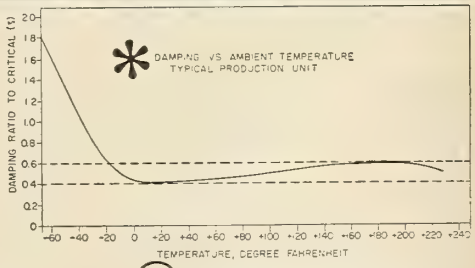
Of at least 12 dogs used so far in the space experiments, the following eight are known: Kudriavka (Curly), Koziavka (Tiny), Damka (Little Lady), Malyshka (Little One), Laika (Barking One), Limonchik (Little Lemon), Albina (Whitey) and Linda (a girl's name of Western, not Russian origin).

Until October 12 the dog handling staff referred to Damka as "the champion of height." The Moscow LITERATURNAYA GAZETA, reported she "was the first living being to reach the highest point without a helmet, in the hermetically sealed cabin of a rocket."

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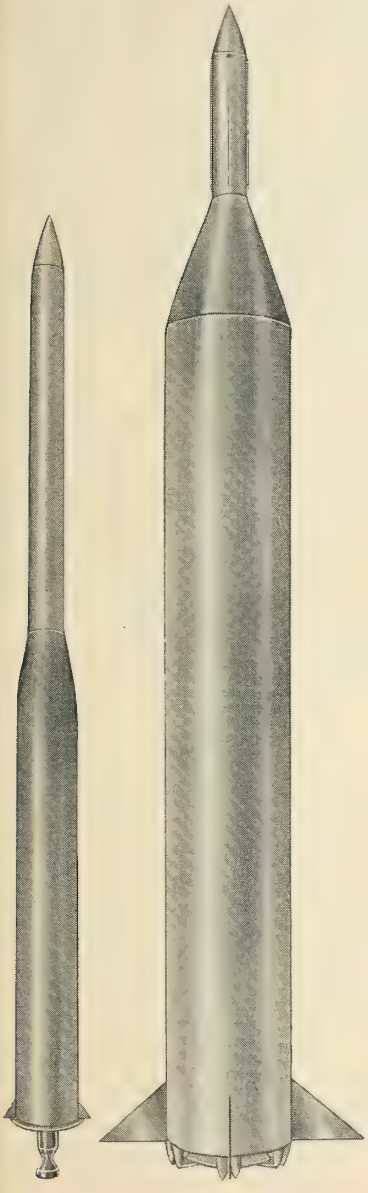
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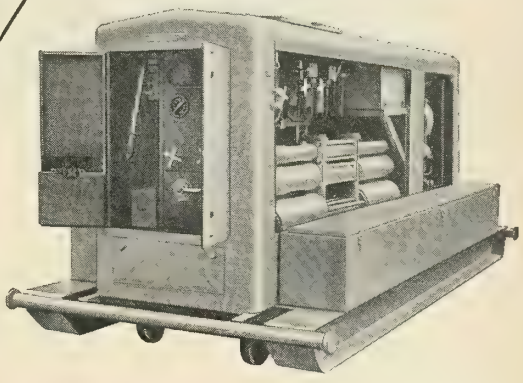
Satellite Carriers: *Vanguard* vs. *Sputnik*



The VANGUARD vehicle (left) will orbit approximately 270 lbs. of satellite (instruments plus empty third stage) at an average altitude of 900 miles. This will require an initial thrust of 100 lbs. for each pound of satellite. The T-2 IRBM SPUTNIK I vehicle (right) launched a total satellite weight of about 1000 lbs. (184 lbs. instruments plus empty T-7A third stage) to an average orbit altitude of 350 miles. SPUTNIK II, essentially a heavier SPUTNIK I with third stage attached, was orbited at an average altitude of 600 miles. Assuming that VANGUARD thrust requirements were met, both SPUTNIKs could have been launched by the T-2 IRBM, which has a thrust of 254,000 lbs.

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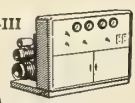
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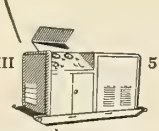
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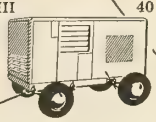
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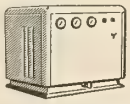
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Russian Space Savants Active In Egypt

The first Soviet astrophysical expedition in the Middle East has begun its activities in the Aswan (Assuan) region of Egypt. The expedition is headed by Academician V. G. Fesenkov.

The Cairo correspondent of TASS, the official Soviet news agency, reports that "the local authorities and inhabitants have met the Soviet expedition warmly and are rendering it all the necessary aid in its work." An Egyptian astronomer, Dr. Adli Salama, has joined the Russian group to participate in its research.

Castable Rocket Propellants Described

ESCH, Germany—Speaking before a German rocket society meeting, Dr. Götz von Francois described cast rocket propellants. Essentially thermoplastic, homogeneous propellant materials used are 50% trinitrotoluene, nitrocellulose, diglycol, and stabilizers. Another combination uses 50% trinitrophenyl glycol nitrate, also with nitrocellulose, diglycol and stabilizers. The cast propellants have a temperature range of 0-50°C and are somewhat less smoky than black powder. Rockets weighing 12-14 pounds, have attained ranges of over 20,000 feet.

Missile Association Makes Rapid Progress

The Association of Missile & Rocket Industries (AMRI) is constantly signing up new members and organizing for service.

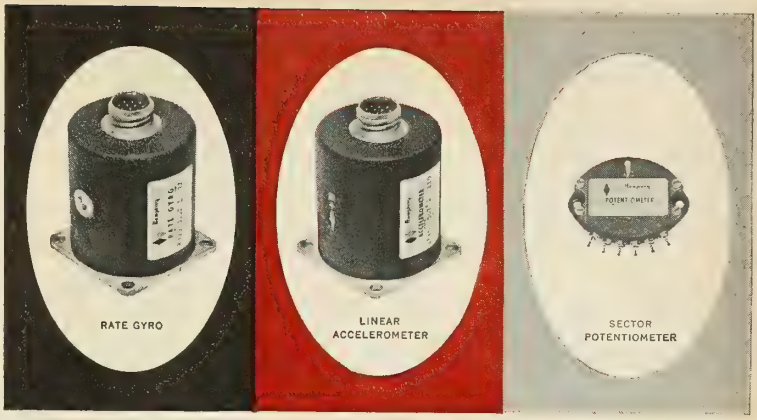
After the second organization meeting in October, attended by representatives of 48 companies, AMRI was incorporated as a nonprofit association in the District of Columbia.

Under an initial board, headed by Adm. J. A. Briggs of the Research Laboratories, Cook Electric Co., the member companies are consulted as a steering committee pending the election of a larger board and a full slate of officers.

Adm. Briggs stresses the importance of "trade association services to help member companies find their place in the missile program." The industry is being canvassed for opinions both as to the AMRI program and questions of national policy.

Committees are being formed on Program, Membership, By-laws, and Statistics.

Kendall K. Hoyt, Executive Director, is opening a suite of offices for AMRI at 1079 National Press Bldg., Washington 4, D.C.



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Sector Potentiometer—Model CP01-0204-1: Cutaway photo shows rugged cast all-metal construction.

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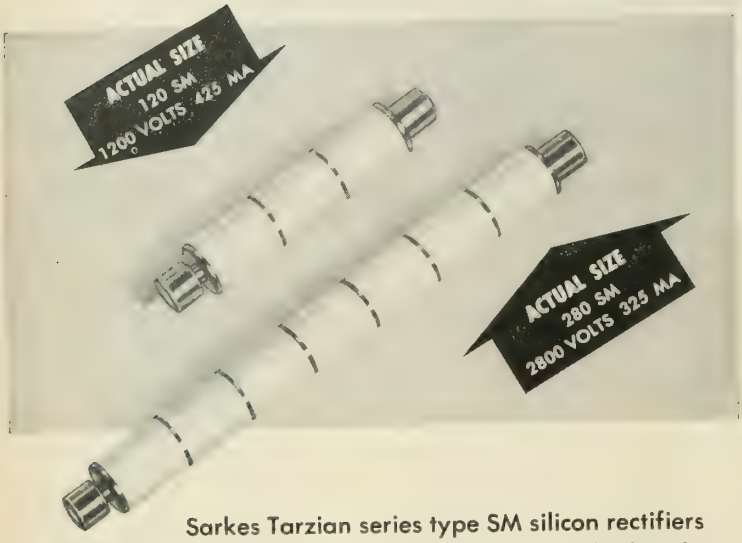
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80SM	800	560	450	.225	1.12	.560	4.5	2.25	27.0	13.5	1N1108
120SM	1200	840	425	212	1.06	530	4.25	2.12	25.5	12.7	1N1109
160SM	1600	1120	.40	.200	1.00	.500	4.00	2 00	24.0	12.0	1N1110
200SM	2000	1400	375	187	940	.470	3.75	1.87	22.5	11.2	1N1111
240SM	2400	1680	.35	.175	.875	.437	3.50	1.75	21.0	10.5	1N1112
280SM	2800	1960	325	162	.812	.405	3.25	1.62	19.5	9.7	1N1113

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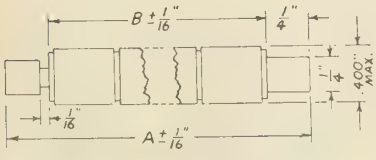


Figure 1

Figure 1 A	Figure 1 B	JETEC NO.
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2-13/32"	1-29/32"	1N1110
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Soviets Now Preparing *Sputnik* Telescope To Probe Mars?

Once a *Sputnik* is beyond the limits of the atmosphere Prof. Y. A. Pobedonostsev of Moscow has announced, a telescope installed on such a satellite will magnify objects 10,000 times their size, instead of the 900-times magnification possible with man's earth bound telescopes. From a *Sputnik*, the Russian scientist said, "objects on the moon which have a diameter of only 12 meters" can thus be observed, and the questions on the so-called "canals" on Mars can be answered. In addition, the character of the surface of Mercury, Venus, Jupiter and Saturn can be studied.

Russia Appoints Space Watchers

The Soviet Union's newest and mightiest ionosphere observing station has recently been installed at Voyeikovo in the Leningrad region. It is manned by a staff assigned to the task by the Leningrad Electrotechnical Institute headed by Prof. M. P. Dolukhanov and Candidate of Technical Sciences E. V. Ryzhkov.

A new meteorite-tracing radar installation is now being built at the Astronomical Institute in Ondrjeev, Czechoslovakia.

Ehricke Proposes Astrophysical Decade

Krafft A. Ehricke, assistant to the technical director of Convair Astronautics, has proposed a ten-year space study program, patterned after the current International Geophysical Year for study of the earth's immediate interplanetary environment and preparation for human travel in space. Ehricke suggested 1965-1975 as an appropriate period for this International Astrophysical Decade.

Power to send IAD research vehicles throughout the inner solar system can be achieved with moderate increases in the capabilities of rocket engines now being built for long-range missiles, Ehricke said. He estimated that these "instrumented comets" can be developed in the next five to ten years.

Space research with instrumented comets holds a tremendous technical, scientific, political and cultural potential, Ehricke stated. He said much fundamental information on the nature of nearby interplanetary space can be learned by launching simple, lightweight bodies capable of reflecting

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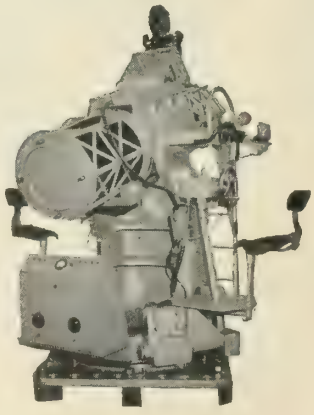
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sunlight, carrying telemetering equipment similar to that to be used in the *Vanguard* satellite project, or carrying hydrogen bombs which, upon detonation, would emit a flash that could be studied spectroscopically from the earth.

One such vehicle proposed by Ehricke could explore interplanetary regions at relatively small expenditures of power. This vehicle, a gas-inflated polyester sphere, could be propelled away from the earth by detachable rocket boosters, then accelerated further by radiation pressure from the sun.

Radiation-propelled spheres 500 to 1000 feet in diameter could carry several hundred pounds of instruments. These vehicles would be useful in exploring the distribution and density of interplanetary matter such as comets, meteors, cosmic dust and gas. Their silver, reflective coating would make it possible for astronomers to follow their progress optically.

H-bomb probes of space would require increased propulsion but could yield much information. These vehicles could be fired on a collision course at the Moon, Mars or Venus and the H-bombs set to explode either on impact or above the surface of the target body. Spectroscopic study of the flash could provide data on atmospheric composition.

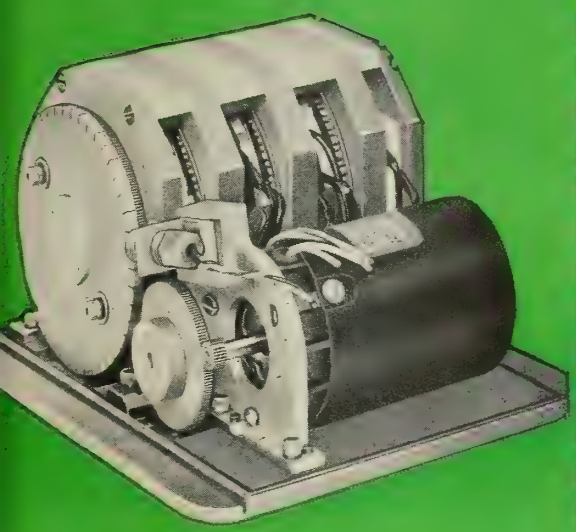
Princeton and Detroit Universities Study Superperoxide Propellant

It has been learned that studies related to the formation of hydrogen superperoxide, H_2O_4 have been underway for several years at at least two U.S. universities—Princeton and the University of Detroit. The Princeton work is being carried out by J. D. McKinley at the Forrestal Research Center under a chemical kinetics project. The project is headed by Dr. Donald J. Kenney of the missile and rocket section.

The USSR has been attempting to synthesize the potential propellant for at least five years. Latest work may indicate that the superperoxide is not a true compound or polymer of ordinary peroxide but may be free oxygen radicals dissolved in H_2O_2. If the theory is proven true it would mean that free radical solutions might be combined with ordinary oxidants or fuels. In this way hydrogen peroxide or nitric acid with free radicals could give substantially higher performance than liquid fluorine or ozone. It might sound the death knell for the boron exotics since a hydrocarbon fuel could be "spiked" with methyl or ethyl radicals.

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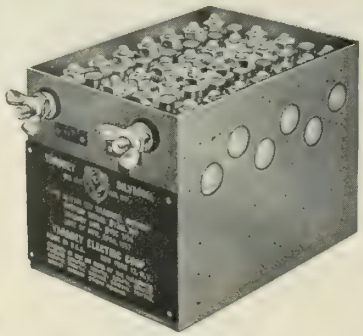
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Solar Activity Confab Held by Reds

IZVESTIA reports a successful conference held at Lvov, western Ukraine, by Soviet scientists concerned with the problems of solar activity and its effect on the Earth. Participants were representatives of scientific organizations of Moscow, Leningrad, Stalinabad (Soviet Central Asia), Irkutsk (Siberia), Riga (Latvia) and other Russian cities.

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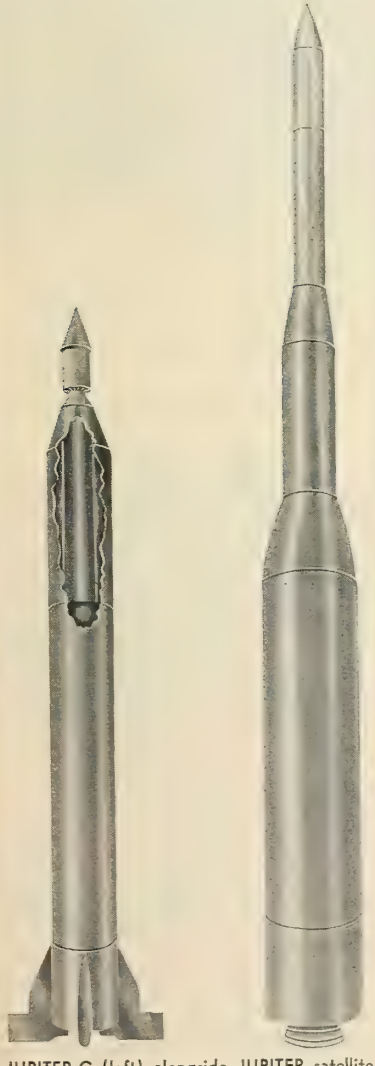
U.S. Army's *Jupiter-C* Becomes Satellite Carrier

The long-awaited decision to place the Army *Jupiter-C* research rocket into the satellite service may not put the United States into space any sooner than was originally planned but it is indicative of a progressive acceptance of the importance of space science. Also, this addition to the U.S. program guarantees only that we will place *a satellite* into an orbit during the IGY.

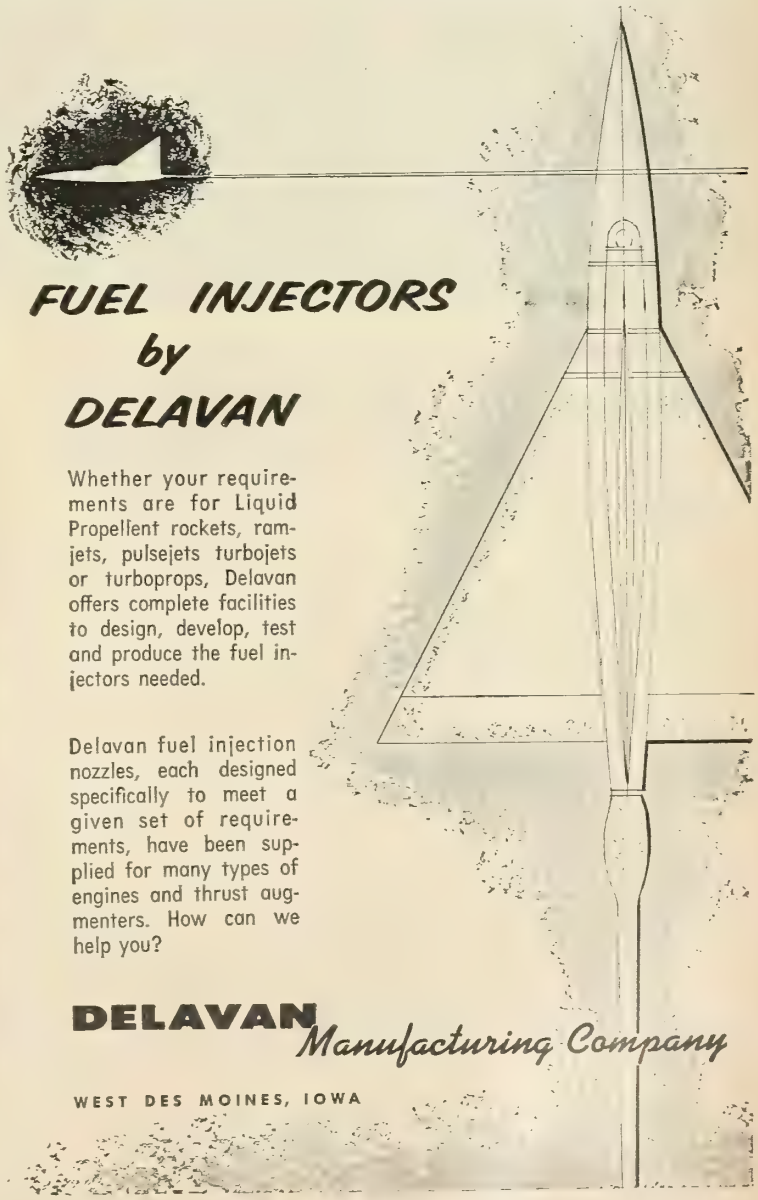
If *Vanguard* and *Jupiter-C* are both successful, it means that we will have *more* satellites of practically the same weight and for basically the same scientific experiments. No plans have been disclosed for placing larger and more varied instrument carriers into space. In addition early reports indicate that the possibilities of the Army orbiting a satellite before the Navy's *Vanguard* are very slim.

The Navy is confident that its first test satellite, to be launched within a matter of days after m/r goes to press, will be successful. If so, the remainder of the test spheres will be shelved and preparations undertaken to launch the first full-size 20-inch satellite immediately. Dr. Hagan, project director, stated this could happen shortly after January 1st.

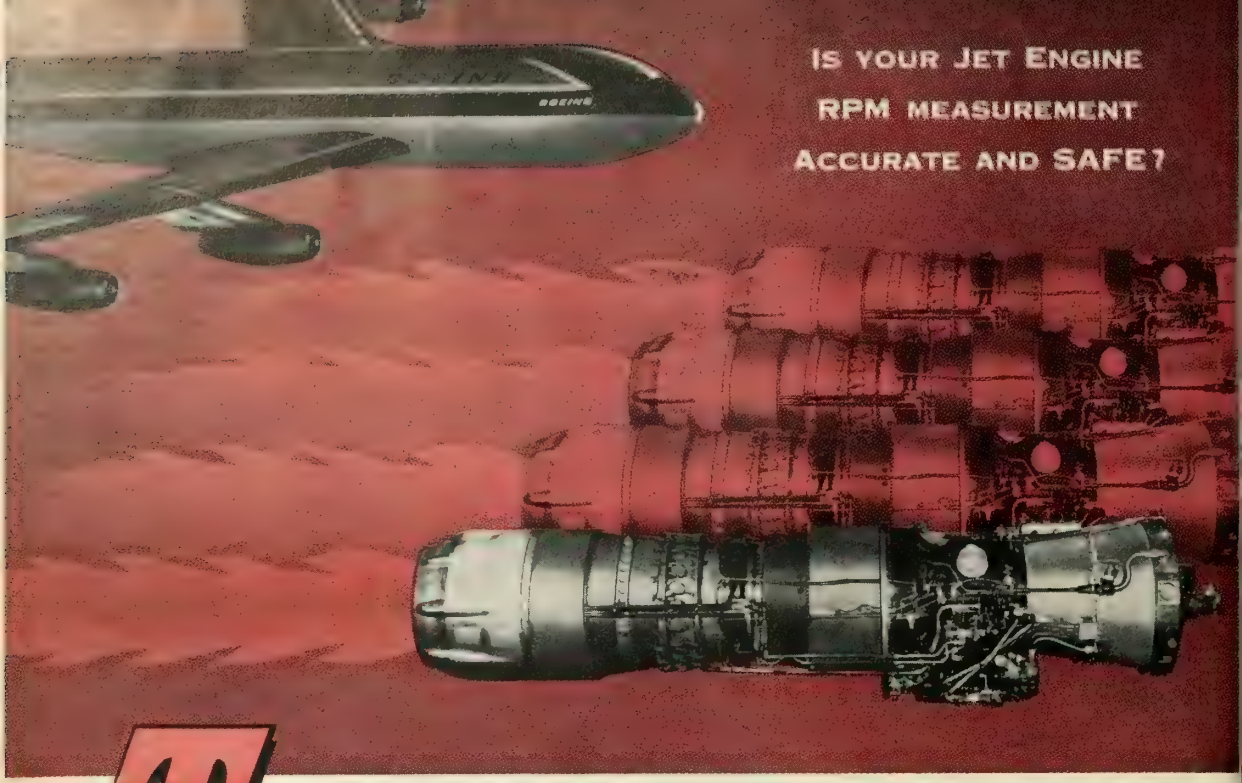
Meanwhile the Army has the task of completing and checking out three *Jupiter-C* vehicles that were left over from the successful nose cone re-entry program. Gen. Medaris emphasized that after the rocket vehicle has been delivered to the launching site, at least 30 days are needed to test and check out the launcher before actual firing. The utilization of the military test vehicle as a carrier has imposed a cloak of security on most of the operation. Sifting of the meager information available indicates that pad-



JUPITER-C (left) alongside JUPITER satellite launcher (JUPITER plus three SERGEANTs, second stage, and one SERGEANT, final stage).



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readiness of satellite-carrier *Jupiter-C* 1 is still several days away.

Army officials further stated that the 20-pound cylindrical satellites are not ready. Jet Propulsion Laboratory will supply the packages. First satellites will be six inches in diameter and over two feet long. Transmitters will broadcast on 108 mg in order that existing Minitrack stations can be utilized. Three to nine launchings have been planned—all "live." Gen. Medaris expects at least a 90 per cent successful orbit capability.

There have been reports that a change in the propulsion system would be necessary before the *Jupiter-C* would be capable of orbiting a satellite. Army officials stated this might involve nothing more than the addition of a fourth stage. The original *Jupiter-C* nose cone re-entry vehicle reached an altitude of 600 miles, a range of 3600 miles and a speed of about 15,000 mph. A configuration and propulsion change could easily force an agonizing stretchout in the program's schedule.

The *Jupiter-C* vehicle is about 70 feet in length with a maximum diameter of six feet. At least three stages will be lashed together in the final configuration. The *Redstone* 300-mile liquid-propellant rocket will comprise the first stage. A cluster of 11 "scaled-down" *Sergeants* will make up the second stage with a cluster of three of these solid-propellant rockets for the final stage. JPL will supply second- and third-stage rockets. Copper Development and an unknown division of General Motors are fabricating the lash-up components. Chrysler and Reynolds Metals will produce the body of the vehicle.

Second- and third-stage rockets and the guidance system will be enclosed within the 29-foot warhead and control section of the modified *Redstone* first stage.

Snark Hits Target At 5000 Miles

The U.S. Air Force's Northrop *Snark* SM-62 has demonstrated ability to send a nuclear warhead to any target in the world with a 5000-mile flight made under simulated operational conditions.

The *Snark*, launched from the Air Force's Missile Test Center at Cape Canveral, Fla., was programmed to impact a target near Ascension Island in the South Atlantic. The subsonic surface-to-surface missile delivered its payload, a simulated hydrogen warhead, on the target with "unprecedented" accuracy.

IMPORTANT DEVELOPMENTS AT JPL



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Sweden Shows Its New Missile Designs

Sweden's first guided missile press demonstration, with the exception of some smaller exhibits at a recent defense exposition in Gothenburg, was held in Stockholm on Nov. 4. At Barkarby outside Stockholm, the Air Force showed its newest weapon, the Type 304 air-to-surface missile developed for the Saab-32 *Lansen* transonic all-weather attack aircraft which is now standard equipment with all Swedish Air Force attack units.

The 304 is currently undergoing extensive trials prior to its introduction into service. It is already in limited production. The new missile was developed by the Swedish Guided Weapons Bureau in collaboration with other governmental and civil organizations. Its production is handled by the Air Force's own central workshops and civil subcontractors.

Very little technical information has been revealed on the 304 except that it is rocket-powered and is fitted with an all-weather guidance system. The missile, two of which can be carried by a *Lansen,* was demonstrated both on the ground and in the air. A fly-by of a *Lansen,* carrying two of the approximately 13-foot-long missiles, showed that the reduction in the airplane's speed is not very great.

The 304 is regarded as an extremely important weapon in Sweden's defense against an invasion over the sea. It will enable the *Lansen* units to fire with utmost precision against enemy naval vessels well outside the range of conventional antiaircraft artillery.

In addition to the Air Force 304 missile, a new naval surface-to-surface guided missile, known as the 315 was shown for the first time. The 315 has been designed for use from destroyer-type vessels against other vessels.

The new missile, now undergoing trials at sea, will initially equip the two new destroyers *Smaland* and *Halland.*

Acceleration to flight speed is provided by four built-in booster rockets. For cruising it uses a special type of jet engine, presumably an advanced type of pulse-jet engine. The missile has an all-weather guidance system. The greatest advantage of the new missile is that it permits firing at targets outside the range of conventional artillery. The missile is 26 feet long.

In general, Swedish guided missile development is handled by the Guided Weapons Bureau. In the future, however, new missile projects will be handled by the aircraft industry, notably Saab. The Swedish policy is to develop only such missiles that cannot be purchased abroad. Guided missiles that can be obtained from abroad will be acquired. One type that will certainly be needed is the surface-to-air missile.



Two Type-304 air-to-surface missiles are shown mounted on Saab-32 LANSEN fighter.



Latest addition to the Swedish fleet is the 315 all-weather surface-to-surface missile.

Washington Trends

by Erik Bergaust



PHILLIPS PETROLEUM HAS TEST FIRED AND DELIVERED several solid-propellant rocket motors of over ¼-million lb./sec. total impulse. Much of the work in progress is directed toward high-energy propellants containing ammonium perchlorate. The company's fabrication processes and techniques permit great grain scale-up with the same plant equipment. This column erroneously reported in September that Phillips was not too interested in these high-energy propellants.

SEVERAL CONGRESSMEN WANT TO KNOW WHO IS FOOLING WHO with all this talk about instant retaliation with an ICBM. The LOX-filled *Atlas* takes over two hours to ready for launching. This time probably will never be reduced to less than an hour. Flight time of a Soviet ICBM is about 30 minutes and our ICBM bases will be the first targets. We could instantly retaliate, assuming our bases are not blasted, only with a solid-fueled ICBM already zeroed in.

CENTRAL INTELLIGENCE AGENCY REPORTS SHOW that the Soviet fleet is now larger than ours. When is the Navy going to tell the public this? The Soviets are not retiring their capital ships. Their submarine fleet (now nearing 600) is unquestionably a major threat. In addition, many of their surface ships can launch rockets and are protected by antiaircraft missiles.

ONE OF PRESIDENT EISENHOWER'S ADVISERS says the Russians have committed a "colossal blunder" by launching their *Sputniks*. We agree that recent events may have awakened the U.S. before the point of no return was reached, but perhaps Mr. Clarence Randall, author of the statement, would like to explain this "colossal blunder" to the millions of people who know little except that two *Sputniks* are up there. As far as these people are concerned, our six-inch satellite will be a "silly bauble" compared with the Soviet versions. And our 21-pounders will be launched at least six months later, at that.

NOW THE PENTAGON IS WISHING that it had paid more attention to the report that Dr. Theodore von Karman prepared for Gen. Hap Arnold in 1945. The report foresaw many of the problems with which we are now faced. It is particularly significant that the general requested the thoughts of Dr. von Karman on two areas of future planning: what assistance should we give to the educational and commercial scientific organizations during peacetime, and what proportion of available money should be allocated to research and development.

Dr. von Karman's prognosis was frighteningly accurate. "No long-range program can possibly succeed unless the proper climate and conditions for its success are provided." We have not provided this climate and 1) we have failed to beat the Soviet Union in the development of an ICBM; 2) we have failed to launch the first earth satellite; 3) we have failed to launch the first earth satellite with an animal aboard; and 4) we shall fail to beat the USSR to the moon.

A THEORETICAL METHOD OF KILLING ICBMs involves the use of a cylindrically bundled photonic beam. Its spectrum lies primarily in the ultraviolet region and it can deliver up to 80 per cent of its energy to the target, despite having to penetrate the atmosphere by as much as 75 miles. Because the reflection of metal is small in the ultraviolet spectrum, the impinging energy of the ray is transformed into heat which vaporizes the body.

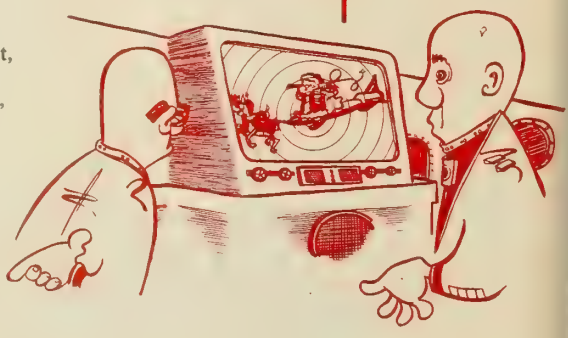
ONE UNUSUALLY WELL-INFORMED CONGRESSMAN wants to know why we don't show the Russians a thing or two by shooting down their *Sputniks*. With what, may I ask?

the flight before Christmas

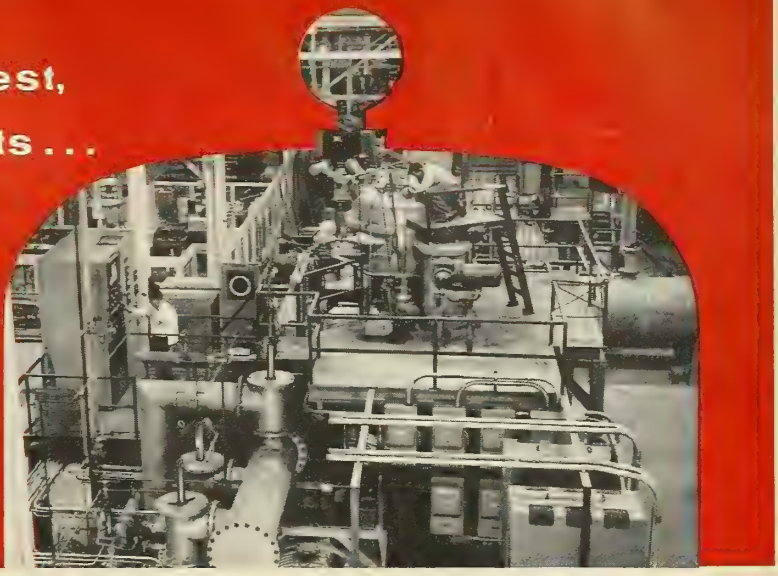


by Jim Carr

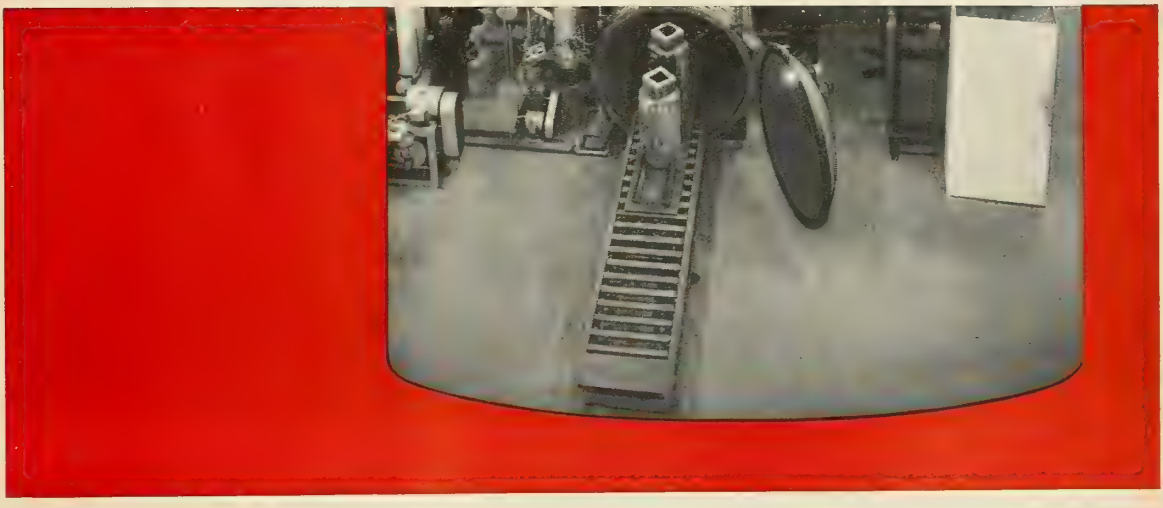
'TWAS the flight before Christmas and through outer space,
Not an object was stirring; support was in place.
The dials were all set in the blockhouse with care,
Checked out were components located there.
Our crew well-secured by a strap in each lap,
The rhythmic countdown had soon caused them to nap.
With the Captain in charge and I on his right,
We blasted away on elliptical flight.
When out in the orbit, there rose such a clatter,
We leaped to our console to check on the matter.
Checked out was each rocket quick as a flash,
A glance at the LOX dial there on the dash.
Moonlight reflecting on earth far below,
Showed nothing amiss in the cold winter's glow.
When what to our wondering eyes should appear,
But a miniature rocket with eight stage of deer.
And manned by a pilot, so lively and quick,
We knew in a moment it must be Saint Nick.
With speed hypersonic, his coursers they came,
He whistled and shouted and called them by name:
"Now Ramo! Now Wooldridge! Now W Dee Dee!
"On Rocketdyne, Convair and ARDC.
"From orbit to orbit to the top of it all,
"Now dash away, dash away, we'll have a ball!"
And then in a twinkle on the scope did appear,
The prancing and pawing of each little deer.
Smooth as a jet stream above a high cloud,
Gathering speed as he nodded and bowed.
He was dressed up for space from his helmet to boot,
With snowflakes adorning his gravity suit.
A bundle of toys he held strapped to his back,
He looked like a Martian adrift from his track.
His visor how frosted, his dimples how merry,
His thrust-reddened cheeks and his nose like a cherry.
With his eyes on the screen of a small radar set,
He was off on the flight plan already pre-set.
Since the course was set up in advance of the flight,
He relaxed with his pipe for the rest of the night.
He had tightened his seat-belt around his fat belly,
But it vibrated some like a bowl full of jelly.
A mighty good spaceman that jolly old elf,
He was better than Schriever—or even myself.
With a little more thrust then applied to the sled,
He dropped off his booster and darted ahead.
A wink of his eye and a wave of his glove,
He aimed for a planet in orbit above.
The flight was prepared in advance on a "brain."
He would find all the stockings without any strain.
To visit all planets in just one night's tour,
He had to be confident, had to be sure.
So he closed a few switches, and turned on the power,
And was out of this world in less than an hour.
But I heard on our set 'ere he soared out of sight,
"HAPPY CHRISTMAS TO ALL AND TO ALL A GOOD FLIGHT."



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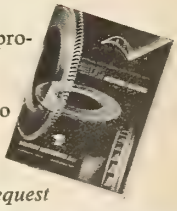


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missile miscellany

This page heard the other day a quip that must be old but is nevertheless worth noting: The Pentagon is the only institution run by its own inmates. All of which leads to a question: If the Army has had missile launching vehicles in being and if it's had its own satellites all ready to go, why is it now changing the vehicle and rebuilding the satellites? Seems as though by doing this, they risk a goof—which it can ill afford at the moment.

Meanwhile, this page also hears reports that Army Ballistic Missile Agency may be set up as the Government's nonservice missile research and development center. This means it would be run by the Department of Defense.

Government must have plenty of selection in space flight projects. A quick check reveals that no fewer than 30 U.S. companies have proposals for putting everything from TV cameras to men into outer space. Some even have suggested ways of getting them back!

Speaking of space, preliminary analysis of telemetered Far Side results indicates that gravity, rather than decreasing simply as the square of the distance from the center of the earth, actually "wobbles"—i.e., both decreases and increases with distance. No attempt to explain this has been made, but there seems to be a possibility that the earth's very strong electrical field and the relatively dense "atmosphere" of charged particles up to 40,000 miles may be a factor.

"What we need in Washington are more eggheads and fewer fatheads" . . . Dr. Fred L. Whipple, "The advancement of science in the U.S. is not up to the scienists, but to top Government planners." . . . Trevor Gardner suggests we drop Vanguard and fire more ICBMs . . . Navy Captain Irwin S. Moore, says the next war, if it comes, will cost the U.S. $4,000,000,000,000 (that's four trillion) . . .

NACA is reported to have given up on magnesium and boron slurries with hydrocarbons as high-energy fuels. Meanwhile, Vitro Corp. reports that it has solved problem of boron deposits in zip-fuel systems. Sounds like another round we had, where no fewer than three different companies claimed credit for having solved Jupiter nose cone re-entry problems. Actually Jupiter nose cone is of machined metal coated with Rockyde. Companies participating in its development include Jet Propulsion Laboratory, Cooper Development, Cook Electric, Norton Abrasives. Contrary to reports, Jupiter nose cone is capable of full velocity re-entry—uses Cook parachute recovery system only after it has re-entered. This is a device designed primarily for research and development rather than for incorporation into an operational weapons system.

Meanwhile, the other day this page was asked what it knew about Sargo, "a transitional missile fired from underwater . . ." Also, if it could put any

light on Big Bear, Middle Bear and Little Bear, another missile project series.

From the West Coast, word that Lockheed has been given a contract or letter of intent to go ahead with a moon rocket; also word of a go-ahead on Pied Piper, that same company's proposal for a reconnaissance satellite. And now a suggestion that homing pigeons raised in Moscow be used as guidance systems for ICBMs. And a note of incidental intelligence—slowing of meson decay at high velocities provides proof of Einstein's General Relativity Theory that things slow down when near-light velocities are reached—clocks run slower, etc. Another relativity calculation—a rod going 161,000 miles per second would shrink to half its length in the direction of flight. Good to know for a flight to Alpha Centauri!

PARIS PRESSE correspondent, Albert Ducrocq, after an extensive visit to Russia reports that Reds are using boron and lithium for propulsion already; also that they've discovered how to store monatomic hydrogen and are using it too. And a suggestion from elsewhere that they have done considerable work—successfully—on propellant systems that emphasize effluxes of greater mass, lower velocity . . . and no doubt anywhere that they're doing quite well at the game.

Many methods of manned re-entry are being suggested and developed. AVCO and Cook Electric are working on parachute devices. AVCO thinks in terms of steel (or other high-temperature material) parachutes—admits structure poses problems. Cook claims it can be done with cloth 'chutes in series. Two Russian re-entry proposals are: Continuous dereefing of a cloth parachute—starts out small and gets bigger as velocity is slowed. Other method would use steel 'chute and come in like a falling leaf. It's been calculated that Sputnik II, if it had popped a 'chute system at its perigee, would have returned safely to earth within 24 hours. Another approach to manned re-entry is much more sophisticated—now in the laboratory development stage—involves magnetohydrodynamics. This works on the principle that a strong magnetic field will bulge out the shock wave in the ionized layer ahead of the re-entering body with double results: drag to slow it down; and less heat transfer due to pushing away of hot air at nose. Also, system can generate its own electric power, picking up current from ionized layer with magnetic coils.

Back to Vanguard again: Stewart Committee that selected Vanguard over Orbiter did not do so with a unanimous decision. Three members of the committee voted against Vanguard, including C. C. Furnas and H. J. Stewart. Minority report is point-by-point and is alleged to make very good reading. And a question: Why has the R&D balance been so much this way . . . . . r&D



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Soviet Affairs

by Dr. Albert Parry

Long before their spectacular triumph with *Sputnik* II, through the years of their preliminary experiments with sending dogs up in rockets, Soviet astroscientists insisted that they were achieving better results than we did with monkeys, mice and guinea pigs. The Soviets said that they were not only reaching higher altitudes with their animals than we with ours, but that we were drugging our animals while Russian dogs were never under narcotics and were thus observed under far more normal conditions. Therefore, Moscow claimed, Russian experiments with "cosmic dogs" were of much greater benefit to space medicine than those made with our monkeys and mice.

So far, this Red claim has gone largely unanswered by our side. If our experimenters have made any reply to the Soviets on this score, the American answer has not been properly publicized. But it should be.

The outburst of indignation from dog lovers regarding *Sputnik* II's passenger is quite puzzling to Russians. As a people they are not so tender hearted toward animals. America's very first Society for Prevention of Cruelty to Animals owes its founding to precisely this Russian hardhearted attitude to animals. The Society was first chartered by the New York State Legislature in 1866 at the suggestion of Henry Bergh, a U.S. diplomat, on his return from Russia. While serving in St. Petersburg as our secretary of the legation (1862-64), he had been outraged by the sight of Russian cabmen mercilessly flogging their fallen horses to bring them back on their feet from the snow or mud. He had also been incensed by the prevailing indifference of Russian passers-by to this cruelty. On coming home to America, and mindful of Britain's legislation and her Royal Society to prevent such cruelty (1822-24), Bergh started a similar movement here.

•

Academician L. I. Sedov, on his return to Moscow from the astronautical meeting at Barcelona (Oct. 6-12), declared that he was "definitely interested" in the papers by U.S. participants at the meeting on "the possibility of building new ion-rocket engines for interplanetary flights;" on "obtaining and utilizing high temperatures up to 30,000 degrees"; on "the development of heat in rockets and artificial satellites while descending and entering into denser strata of the atmosphere."

Sedov also expressed "indubitable interest" in "reports devoted to oriented artificial satellites and certain other problems of aerodynamics" such as the report on sending plastic balloons up to great heights.

On his return from a visit to the United States, Prof. Anatoly Blagonravov also expressed his interest in American rocket firing from balloons (Operation *Far Side*). These experiments were "worthy of attention" of the Soviets, he said.

The above list can tell us just where the Russians now feel they are either behind us and can learn things from us, or are on a par with us but should be ahead.

•

The latest Soviet humor at our expense includes the quip that Americans piled up mountains of talk and preparations and haven't produced even a *Mouse*.

And why should Americans worry so much about Syria, jests a Moscow humorist, when they had better do something about flights to Sirius.

Sirius, we may add, is also known as Canis Majoris or Dog Star.



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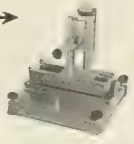
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World Astronautics



by Frederick C. Durant III

Details have just been received on the First Polish Scientific Conference on Rockets and Astronautics held in Warsaw last Spring. Host and organizing body was the Polskie Towarzystwo Astronauticzne. After hearing a tribute by Prof. Dr. E. Olszewski to the 100th anniversary of the birth of Russian rocket pioneer K. E. Tsiolkowski, about 200 "specialists in rocket technology, thermodynamics, aerodynamics, physics and biology and astronomy" settled down to listen to 21 technical papers. Prof. Z. Paczkowski detailed current problems in rocket development and Dr. K. Zarankiewicz (president of the Polish Astronautical Society) outlined the current status of astronautics. All meetings were held at the Warsaw Polytechnic Institute.

Subsequent topics treated in technical papers included ion propulsion (Prof. M. Lunc, L. Bobrowski); nuclear propulsion (O. Wolczek); water-steam rockets (J. Walczewski); turbojet engines (Dr. S. Wojcicki).

Thermodynamics and technology of liquid and solid propellants were covered in papers by M. Zembrzuski, Heger, Bodaniuk and Chrzanowski. Inertial guidance systems were treated by A. Kaczmarczyk. M. Subotowicz presented a concept for achieving propellant economies in a step-rocket system.

Ballistics and guidance systems were discussed by W. Biwan, J. Pie-Kielny, F. Wolnica and Lizon. Rocket jet throttling was treated by Ulam and materials of construction by H. Muster.

On the final day the future was examined and applications of nuclear energy to space flight were considered by S. Wilk. The Polish Society Secretary, W. Geisler, introduced the possibility of using asteroids as earth satellites. An analysis of the case of the planetoid Hermes was treated in particular. Dr. Gadomski presented the results of his calculations on the existence of ecosphere about other stars. His conclusions were that of the 50 stars nearest to the solar system, only 13 could possess an ecosphere which could result in organic life similar to the Earth's. Space medical problems were treated by Dr. Oginski, W. Ciechocinski and Col. Dr. S. Marczewski.

The rocket and astronautical exhibition which had attracted 80,000 people in Silesia (m/r February, pp. 74, 75) was opened in the Warsaw Museum of Technical Science.

In summary, the Polish Astronautical Society gave evidence of deep interest and a sophisticated appreciation of astronautics.

•

In Boston last month re-entry expert Dr. Arthur Kantrowitz, Director of the Avco Research Laboratory announced that Avco had been "studying the problems of manned re-entry for more than a year." He went on to state that "a manned satellite vehicle could be accomplished much more quickly than commonly supposed."

•

For those who still are looking for justification of scientific research in space, we give you the opinion of famed Russian scientist Peter L. Kapitsa:

> ". . . if in any branch of knowledge, possibilities of penetrating a new virgin field of investigation are opening, then it must be done without fail, because the history of science teaches that, as a rule, it is precisely this penetration of new fields that leads to the discovery of those very important phenomena of nature which most significantly widen the paths of development of human culture . . ."



Space Medicine

by Hubertus Strughold, M.D., Ph.D.

U.S. highlight of the International Astronautical Congress in Barcelona, Spain, from 7 to 11 October 1957 was—without question—the report on the recent balloon flight to 102,000 feet by Major David G. Simons. Dr. Simons, Chief of the Space Biology Branch of the Aeromedical Field Laboratory, presented a paper giving his observations during the flight.

Dr. Jan Gadomski, a member of the Polish delegation, delivered a paper on "Star Ecospheres Within a Distance of Seventeen Light Years from the Sun." Dr. Gadomski had screened the numerous stars within this area, and had concluded that only 20 of them could have ecospheres—that is, zones containing planets with conditions favorable to life.

In her paper on "Preparations for Visual Observation of Artificial Earth Satellites," Dr. Alla T. Masevich, an astrophysicist and member of the Soviet Academy of Sciences, who heads about 24 satellite-tracking stations, mentioned that she had some difficulties in persuading an optical factory near Moscow to build special telescopes of the small size needed by her moonwatchers. The factory officials felt that simple binoculars would serve the purpose. After Dr. Masevich and her colleagues gave the factory staff a series of lectures on the meaning and importance of the satellite-tracking project, they not only supplied the telescopes but also established a moonwatch station in their territory.

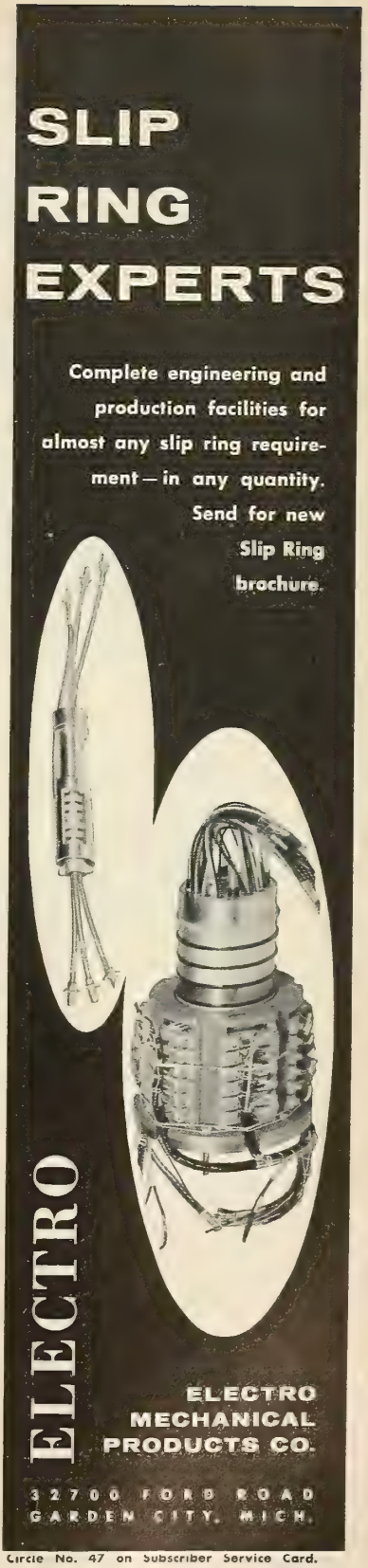
Prof. Leonard Sedov, leader of the Soviet delegation, made an interesting remark in the course of conversation at the Barcelona meeting. He said: "The important question is not whether a country has a bureaucracy. The question is how much of a bureaucracy the country has."

Dr. Ingeborg Schmidt of the Department of Optometry at the University of Indiana in Bloomington presented a paper at the same meeting on the visibility of satellites in an equatorial orbit. The nucleus of her research was a concept of "areas of potential visibility." The calculations given by Dr. Schmidt for the visibility of equatorial satellites have also turned out to be correct for a satellite of the polar or semipolar type.

In Wiesbaden, Germany, a few days after the Barcelona Congress, Maj. Gen. Harry G. Armstrong, Surgeon of the U.S. Air Force in Europe, arranged a press conference with Maj. Simons and the writer on matters of space medicine. The fact that 60 newspapers from all over Europe sent correspondents to this conference indicated a great deal of popular interest in the subject.

During the week of 27 January 1958, at the meeting of the Institute of the Aeronautical Sciences in New York City, a symposium on "Aeromedical Considerations in Space and Space-Equivalent Flight" will be held. The chairman will be Maj. Gen. Otis O. Benson, Jr., Commandant of the School of Aviation Medicine.

Seven papers will be presented in the symposium. They include "Medical Challenge on the Vertical Frontier," "The Environment of Space in Human Flight," "Supersonic and Hypersonic Flight," "Biodynamics in Human Flight," "Cybernetics in Human Flight," "Future Prospects in Human Flight," and "Interrelation of Space Medicine with Other Fields of Science."



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MG-61	27.5	126	115	1	1750	50,000	54	53C6767
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32E03-3	27.5	150	115	1	2500	50,000	58	53B6227
*32E03-8	27.5	160	115	1	2500	50,000	65	53B6227
*MG-77	27.5	150	115/200	3	2500	50,000	65	—
*32B49	27.5	160	115/200	1 3	2500 2500	50,000	65	E54807
MG-81	27.5	160	115/200	1 3	2500 3000	50,000	61	E1725
MG-95	27.5	160	115/200	1 3	2500 3000	50,000	58	E54807
32E09	27.5	160	115	1 3	2500 3000	50,000	60	—
32B27	27.5	285	115/200	1 3	3500 4000	50,000	76	—

*These inverters have magnetic amplifier "static" type voltage and frequency regulators.
NOTE: D.C. Input Voltage shown is nominal value of 27.5 volts, but all units are designed for 26 to 29 volt operation. Input amperes shown are rated at 27.5 volts input.

Red Bank DIVISION

Bendix AVIATION CORPORATION

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missiles and rockets
MAGAZINE OF WORLD ASTRONAUTICS

m/r exclusive:

Education and Industry

An m/r sampling of missile job requirements

EDUCATION means a great deal to your business. If you're in the market for competent, technically trained men, you know the problem. They're hard to come by. And, if you think it's bad now, look ahead: it's going to get worse.

Here are some figures worthy of consideration: The year 1950 shows the highest number of college graduates ever to receive their bachelors' degrees—434,000. By 1955, however, the total had dropped to 287,000, as those delayed by World War II completed their education under the G.I. Bill and the number of students entering college returned to normal.

This story is in three parts. One you've just read. The next is a brief rundown on universities with an interest in the missiles and rockets field. The last part concerns itself with a sampling of missile industry recruiting needs.

What Colleges and Universities are doing in Rockets and Missiles

By the end of the war three universities had established courses in rocketry and related subjects at various levels. These "big 3"—California Institute of Technology, Princeton University and Purdue University—are now being joined by a growing number of schools around the nation.

California Institute of Technology, Pasadena, Calif.: Through its Guggenheim Aeronautical Laboratory (GALCIT) and Jet Propulsion Laboratory, this technology center was the pioneer in fostering the rocket sciences in the U.S. under Theodore von Karman. Present staff consists of Clark B. Milliken, professor of aeronautics (also Chairman of the Board of JPL). E. E. Sechler, A. L. Klein, H. W. Liepmann and H. J. Stewart, all professors of Aeronautics.

Although JPL is administered quite separately from GALCIT, close contact and cooperation are maintained.

University of California at Los Angeles: Recently instituted is a full-scale course in space technology which is being coordinated by H. S. Seifert (Guided Missile Div. of Ramo-Wooldridge Corp.). The course will consist of 2½ hours of lectures each week. Each lecture will be presented in Los Angeles, San Diego and San Francisco, in order to reach the widest possible audience. The lectures will run from Jan. 13, 1958 to May 19, 1958.

All students taking the course must have a technical degree for this first-year graduate-level course.

Following the last lecture, Simon Ramo, H. G. Stever (MIT), Arthur Kantrowitz (AVCO), and R. W. Porter (GE) will form a panel to discuss the progress and problems in the space sciences.

Case Institute of Technology, Cleveland, Ohio: A technical school, Case is interested in the propulsion sciences. H. W. Burlage is director of the Propulsion Laboratory and D. W. Steel heads up the Nuclear Center Project.

Columbia University, New York City: Columbia is interested in materials and has an Institute of Flight Structures, directed by Hans H. Bleich.

Cornell University, Ithaca, N. Y.: The Cornell Aeronautical Laboratory is a nonprofit organization which is wholly owned by the university. Dr. Clifford C. Furnas directed the laboratory operation from its inception in 1946 to 1954, when he became Assistant Secretary of Defense for Research and Development. In 1956, some 1,200 persons were employed here on missile and related projects. The budget is currently at over the $1-million-per-month level.

University of Detroit, Detroit: Currently organizing its Missile and Rocket Section (MARS) to include the research facilities of the 26 other Jesuit schools in the United States. Instructors include: Dr. D. J. Kenney (chemistry) and monopropellant expert Dr. J. A. Hannum (reaction kinetics).

Illinois Institute of Technology, Chicago: Two of the exotic projects at Armour Research Foundation (independent from but associated with Illinois Tech) are stabilization of liquid ozone and boron hydride research. The 24-block Technology Center near south side Chicago has more than 7,500 undergraduate and graduate students in engineering and liberal studies.

Johns Hopkins University, Baltimore: Operates the famous Applied Physics Laboratory at Maryland locations in Silver Spring and nearby Howard County. Organized in 1942, for work on guided missiles, the laboratory has worked on *Terrier* and *Talos* missiles. Of the staff of 1,300, 525 are scientists and engineers.

University of Maryland, College Park, Md.: Sparked by Prof. S. F. Singer, the Physics Department has played a leading role in high-altitude and satellite research. Projects have

included: MOUSE, *Terrapin* and *Far Side*.

Massachusetts Institute of Technology, Cambridge, Mass.: In addition to conventional instruction and training in the pertinent phases of missile technology, MIT also has available a unique student-operated test facility. The MIT Rocket Research Society designs, constructs and tests liquid and solid rockets.

University of Michigan, Ann Arbor, Mich.: Through its Engineering Research Institute (R. G. Folsom, director) and Willow Run Research Center, Michigan has allowed students to participate in such early projects as *Bomarc* and *Wizard*. Its aeronautical center is now located in a new north campus site and under the direction of Professors T. C. Adamson, R. B. Morrison (shock tubes and ramjets) and D. E. Rogers (rockets).

New Mexico College of Agricultural and Mining Arts, State College, N. M.: Fast rising is this missile-minded school, which offers courses related to missiles and rockets in math, physics, and engineering. It operates a program in cooperation with White Sands Proving Grounds. About 250 students are involved. The Physical Science Laboratory has a budget of $2 million for work on satellites, rockets and ECM.

New York University, New York City: This Manhattan school has been particularly active in the propulsion sciences under its chemical engineering department (J. Happel, C. J. Marsel and P. F. Winternitz).

Northwestern University, Evanston, Ill.: Strong point has been fluid mechanics under Prof. Ali Bulent Cambel.

Ohio State University, Columbus, Ohio: Research activities in rockets has included liquid hydrogen rockets and premixed propellants.

Polytechnic Institute of Brooklyn, Brooklyn, N. Y.: Starting in the Fall of 1957, Brooklyn Poly offers a graduate course in rockets and rocketry. Under the directorship of Dr. T. P. Torda, professor of chemical engineering.

Princeton University, Princeton, N. J.: Through its James Forrestal Research Center, Princeton offers the student a chance for graduate research. Operates a rocket test facility. Notable staff members are: Profs. Martin Summerfield and Luigi Crocco, both Robert H. Goddard professors.

Purdue University, West Lafayette, Ind.: In Sept. 1946, Purdue offered its first undergraduate course in jet propulsion. It also offers graduate instruction and research in rockets. Operates a rocket test facility and has done much work in nitric acid systems.

Temple University, Philadelphia: Its Research Institute has been working on high-temperature flame reactions for several years, *viz.*, ozone fluorine.

Wayne State University, Detroit: Dr. G. P. Loweke teaches the course, "Mechanics of Space Flight Orbits."

That, in brief, is what you can expect to find in the way of formalized educational opportunities in missile engineering and associated fields. A few colleges and universities have taken steps to adjust their curricula to the changing times, but it's a spotty effort at best.

Now take a look at the kind of people that industry needs now and you get an idea of the magnitude of the problem 10 years from now. What follows is a sampling of industry's demands for technical help. A survey of every company in the entire industry would reveal even more critical needs.

Lockheed Aircraft Corp.
Missile Systems Division
Sunnyvale, Calif.

Lockheed Aircraft Corp. has positions generally available for engineers and scientists with training and experience, preferably in the missile field, in the following branches: aerodynamics, thermodynamics, guidance and controls, weight systems analysis, antennas & propagation, propulsion, flight dynamics, instrumentation, telemetering, basic loads and structures.

The company has new facilities in the Bay area at Sunnyvale and in Stanford's Industrial Park, Palo Alto, as well as a plant in Van Nuys, Calif. In addition a 4000-acre static test site, located in the Santa Cruz mountains, and flight test bases at the Air Force Missile Development Center, Alamogordo, N. M., and Patrick Air Force Base, Florida.

Flexonics Corp.
1315 South Third Avenue
Maywood, Ill.

Flexonics Corp. was founded in 1902 as the Chicago Tubing and Braiding Co. and at first manufactured only Kantleke gas appliance hose. The company pioneered the development of flexible metal hose in America.

These positions are available or likely to be available at the Research and Development Division, Elgin, Ill., and the Santa Ana Division, Santa Ana, Calif—engineering and product design. Salary open.

Employe relations features include: promotion from within whenever possible; progress reviews twice yearly, paid vacations, retirement (profit-sharing plan), credit union, group insurance, hospitalization, lost time, major medical and dread diseases. Working hours, 40 per week; overtime when authorized.

Raytheon Manufacturing Co.
Waltham 54, Mass.

Raytheon's president, Charles F. Adams, says: "The employment outlook at Raytheon is good. In the fast-moving missile field, our own experience, coupled with national and international events in recent weeks, leads me to believe that there will be a steady expansion of activity in the foreseeable future. This growth calls chiefly for high-caliber, creative engineers in the electronics and aeronautical fields, as well as mathematicians and physicists, and for experts in production engineering who can adapt the electromechanical developments to manufacturing processes.

"Raytheon is seeking electrical engineers, mechanical engineers and physicists for research, development, design and application engineering positions in the fields of guided missiles, electronic equipment (radar, communications, etc.), electron tubes and semiconductor devices. We have a particular need at the present time for engineers with experience in microwave circuitry and/or components. Salaries range up to $12,000. Most of these positions are at the various Raytheon plant locations in Eastern Mass."

Consolidated Electrodynamics Corp.
300 North Sierra Madre Villa
Pasadena, Calif.

Missile expenditures, the electronics industry, according to a recent report, may account for more than $750 million of the $2.5 billion presently allocated for the missile program. In looking ahead, needs will accelerate for development engineers having training and experience in the fields of data reduction, magnetic-tape data processing and transistor circuits. Openings in the categories mentioned will be in the Pasadena, Calif. area. Meanwhile, there is not much in the way of immediate employment opportunities at this time.

Republic Aviation Corp.
Farmingdale,
Long Island, N. Y.

Present openings are for electronics engineers, flight control engineers, engineering laboratory technicians and missile test engineers.

Future openings are in all fields, particularly for engineers with experience in missile guidance, advanced electronic techniques, radar, IR, UHF, SHF, power plants and boosters, nuclear physics, antennas, aerodynamics, thermodynamics, operations research, human engineering, production cost analysis, weights and balance, computer systems, telemetering, structural analysis, servomechanisms and navigation systems. The salary ranges in these fields will be $120 to $250 per week for nonsupervisory positions. All the above positions will be at the Guided Missile Division facilities at Mineola and Hicksville.

Guided Missiles Division has in the past and will continue in the future to make advancements from within whenever possible. All the benefits applicable to the other divisions of Republic Aviation Corp. are available to the employes of this division such as: paid vacation, eight paid holidays per year, liberal pension plan, company-paid medical, surgical and hospitalization insurance.

The Garrett Corp.
9851-9951 Sepulveda Boulevard
Los Angeles 45, Calif.

At present, due largely to unsettled financial conditions in the Department of Defense, it is not likely that this company will be hiring any new engineers at all for some time except in isolated cases of necessity.

Acoustica Associates, Inc.
Shore Road
Glenwood Landing, L. I., N. Y.

This company is an associate contractor in the Atlas ICBM program and has been engaged in development work for the Air Force for almost two years. Positions open for trained personnel range from electronic technicians to project engineers. Positions are available at our main plant in Mineola, L. I., at our testing station in Glenwood Landing, L. I., and our west coast office in Los Angeles. Salaries range from roughly $75 per week for beginning technicians to over $15,000 per year for professional people. All the usual employe benefits such as company paid hospitalization and paid vacations are in effect.

Key employes participate in a stock option plan. Engineers are given every opportunity to expand professionally and to assume greater responsibilities.

Aro, Inc.
Tullahoma, Tenn.

Aro's managing director, R. M. Williams, says: "During the next eight months, Aro, Inc., will probably hire from 15 to 20 recent college graduate engineers for junior staff positions and from 30 to 35 experienced engineers. Our requirements are mainly for those with aeronautical, mechanical and electrical degrees and for physicists. There will be little change in our work force of 2,100 people."

Aro, Inc., is a private corporation, a subsidiary of Sverdrup and Parcel, Inc. of St. Louis, Mo. It was formed in 1950 and is directly concerned with the task of developing new and improved wind-tunnel testing techniques and equipment. There has been a steady, gradual growth from a payroll of less than a hundred to the current 2,100 level. Salaries range from a starting level of about $5,000 to more than $15,000 for top engineering staff assignments.

Advantages of working for Aro, Inc. are as follows: semiannual salary increases, moderate climate and good geographical location, excellent housing, graduate program (resident faculty) providing an opportunity to earn master's degree, relocating expenses, two weeks and two days vacation per year, excellent technical library, assignment to test projects involving advanced and future trends in missiles.

Aerotest Laboratories, Inc.
129-11 18th Ave.
College Point 56, N. Y.

Employment outlook for this company is good. It is expanding its facilities to accommodate the new and additional missile-component testing, which require a new type of employe, one who must be highly imaginative and have a solid analytical and theoretical background.

Advancements are based upon ability, experience and length of service. Salaries are reviewed periodically and raises are given on merit and length of service. Employees receive two weeks vacation yearly. The company provides an insurance program, including medical benefits. A Blue Cross program is in effect. For engineering personnel there are graded overtime payments, unlimited sick leave. For technical personnel, time-and-a-half overtime payments with limited sick leave. Annual bonuses are given to all personnel.

Marquardt Aircraft Co.
16555 Saticoy St.
P. O. Box 2013—South Annex
Van Nuys, Calif.

With respect to technical personnel requirements, Marquardt is interested in quality, rather than quantity of engineers and scientists. The fields of work in which this company is engaged present such a scope and challenge that it requires technical people of superior ability who have the initiative and imagination to push forward into unexplored technological areas. As to numbers of technical people, requirements are based somewhat on the contribution offered by the individual. The man often makes the job and, if the right kind of talent comes along, Marquardt is in a position to create the job to utilize these talents.

All promotions and salary increases are made on a merit basis. Each employe is evaluated twice a year to insure that his contribution is recognized. The benefits plan includes group insurance, retirement, paid vacations and sick leave.

The Electric Storage Battery Co.
12 South 12th St.
Philadelphia 7, Pa.

The Electric Storage Battery Co., Philadelphia, seeks qualified personnel for its expanding missile battery program. Needed are electrical, mechanical and metallurgical engineers and technicians to join its staff of missile and battery experts. Jobs are available at Exide Industrial Division's Philadelphia plant. Engineers and technicians wishing to join in this expanding program may send applications to: Manager of Industrial Relations, The Electric Storage Battery Co., Box 8109, Philadelphia 1, Pa.

The company has a schedule of eight holidays and paid vacations for periods up to four weeks, depending upon length of service. A job evaluation plan and annual salary review assure that no employee is overlooked.

For employes who wish to further their education and enhance their value to the company, a system of tuition refunds is in effect. A patent award system and a suggestion system provide other means of recognition and remuneration.

Convair
A Div. of General Dynamics Corp.
General Office
San Diego 12, Calif.

Employment at Convair-Astronautics is about 6800 at the plant and 1700 at the various test bases. Under present programming for the *Atlas* the level probably will stay at 8500 for some time to come. The division is looking for senior level engineers in such fields as electronics and operations analysis.

Engineers' salaries are reviewed for increases twice yearly. Vacations are two weeks annually (three weeks annually after 12 years). Full group hospitalization insurance that extends to the entire family is available. A retirement plan under which employe contributions are matched by the company is reputedly one of the most generous in the industry. Overtime pay is somewhat restricted.

Narmco Resins and Coating Co.
600 Victoria St.
Coasta Nesa, Calif.

Narmco Resins and Coatings Co. is a member of a group of companies, first founded in 1944 by Dr. G. G. Havens as a research and development organization.

The company is presently devoting considerable time to the research and development of higher-temperature resistant adhesives for missile application. As the demand for missile materials increases, it is natural to assume that the demand for more highly skilled technical people will also increase.

The Narmco philosophy relative to advancement is to develop its own people within the company and grant advancement in accordance with ability and performance. The company is nonunion, rates of pay are equal to or higher than the average rates being paid by similar companies. Narmco grants a two-week paid vacation to all employes after one year; three weeks after ten years employment.

Burroughs Corp.
Defense Contracts Organization
Detroit 32, Mich.

Total employment has increased from 300 in 1954 to nearly 2000 scientists, engineers and technicians today. The Ballistic Missile Division employs more than 200 people. They are engaged in the design, development and prototype construction of the large-scale special purpose computer, which forms the nerve center of the controls in a ballistic missile system.

A Military Field Services Division now numbers more than 1000 people. Its work includes the preparation of detailed technical manuals, specialized training of technical manpower, site planning, preinstallation preparation of equipment, delivery, installation, and listing. These facts indicate the opportunities for scientists, technicians, engineers, and staff people in this area of the business.

Ronan and Kunzl, Inc.
Marshall, Mich.

This is a medium-sized company well established as a leader in the missile field producing cryogenic equipment.

There are no specialists at Ronan & Kunzl, Inc. Well-rounded and fully developed engineers result from this policy.

As ability is shown, advancement is certain.

Starting salaries are based on experience and range from $400 to $700 per month for a 40-hour week. Overtime is paid on a straight time rate. A profit-sharing bonus has been in effect during the past three years. Also offered is an excellent hospitalization and major medical insurance plan, partly paid by the company. Paid vacations are: one week after one year's employment, two weeks after three years and three weeks after ten years.

Chrysler Corp.
Defense Operations Division
P. O. Box 1687
Detroit 31, Mich.

Five years ago, Chrysler Corp. established a Missile Operations Branch in Sterling, Mich., and began working under the direction of the Army Ballistic Missile Agency in the Redstone Ballistic Missile Program. In June 1956, Chrysler was awarded an engineering and production contract on the *Jupiter* intermediate-range ballistic missile. At present, the *Redstone* and *Jupiter* missile systems projects and the ground-handling and launching equipment programs are expanding.

Positions are available in research, fabrication and assembly, and field operations. Expansion in development work has provided new opportunities for electrical, mechanical, power plant, structures and production engineers in design, laboratory and fabrication and assembly activities. Positions are also open for technical writers with electronic specialization, project planning engineers and field service engineers.

North American Aviation Inc.
Missile Development Division
International Airport
Los Angeles 45, Calif.

The Missile Development Division, following the *Navaho* cancellation, has been pretty well shaken down and is trying to project what jobs are available. It has shrunk from about 7100 to approximately 2100 at the present. The ASM is now our major missile project. It's growth potential looks good, but the division only now is entering the development stage.

North American Rocketdyne
6633 Canoga Ave.
Canoga Park, Calif.

This company is in the market for:

Analytical and theoretical engineers with master's degree in physics or mechanical engineering, and substantial theoretical work in mathematics, fluid flow, heat transfer, thermodynamics, servo and control systems, combustion, and elasticity.

Graduate mechanical engineers with substantial course work in vibration, heat transfer, and mathematics.

Research engineers possessing advanced degrees and considerable study of heat transfer, fluid flow, and mathematics.

Engineering specialists with master's degrees in mechanical engineering and study in advanced thermodynamics and/or aerodynamics.

Design and/or research engineers with M.E., E.E., or Ch.E. degrees for electrical, pneumatic, mechanical and electronic control devices.

Research engineers with advanced degrees in physics or mechanical engineering and strong theoretical background in mathematics; experience in analytical development of complex physical phenomena observed in propulsion systems and component development.

Mechanical engineers with strong background in analysis of complex design proposals of advanced concepts of rocket-engine systems.

Research engineer with advanced degree (master's degree and preferably a Ph.D.) in the field of compressible flow, gas dynamics, fluid mechanics, with experience associated with some aspect of internal flow regimes.

Physicists or electronic engineers with Ph.D. degree and strong theoretical mathematics, and electronic background, capable of original thinking.

Ph.D. in mathematics or physics, with a strong background of training in quantum mechanics, classical mechanics, thermodynamics, kinetic theory and electromagnetic theory.

Physicists with Ph.D. degrees and experience in nuclear engineering to study the application of nuclear power for propulsion.

Sperry Gyroscope Co.
Division of Sperry Rand Corp.
Great Neck, N. Y.

Sperry Gyroscope Co. is extensively involved in missile work and pioneered a number of employe relations and employe benefit activities dating back a number of years.

The company will have a decrease in work force of about 300 by the end of the year and an additional 200 to 300 in the early months of 1958, after which, Sperry Gyroscope predicts a building-up again so that they will return to, or above, their present work force of 17,400. Part of this build-up is based upon increased activity in the missile field.

At present, the company is involved in 12 missile projects ranging from complete weapon system responsibility through development and production of subsystems on down to inertial devices, instrumentation and automatic checkout equipment.

Ampex Corp.
Redwood City, Calif.

Ampex Corp. is not a prime contractor in the missile field, but manufactures major components, *e.g.,* magnetic-tape recording systems for telemetry and test. Employment levels are not directly responsive to defense business since the company manufactures magnetic-tape recording equipment for consumer and professional broadcast and television use.

Robert Sackman, vice president and general manager, says: "I feel that after a period of reappraisal at top level in the Administration, probably by the President himself, the missile program will take its place in fact, not just in words, as the Number One defense job of the country. All firms directly and indirectly connected with this industry will feel the impact of increased business in the late winter and early spring as the result of this decision."

Phillips Petroleum Co.
Bartlesville, Okla.

The growth of Phillips Petroleum Co. has been phenomenal—from a $3-million corporation with 27 employes in 1917 to a corporation with assets of more than a billion dollars and more than 27,000 employees. The company's planned expansion and diversity of products should provide for continued, steady growth and a high level of stability.

In 1951, with extensive investigations of rocket fuels from petroleum-based materials already accomplished, Phillips was selected by the U.S. Air Force from more than 30 firms as contractor-operator of Air Force Plant No. 66 near McGregor, Tex., for the development and production of solid fuels for rockets of the "jet-assist-take-off" (JATO) type. This is the only solid-propellant rocket engine employing this kind of fuel which meets all Air Force performance requirements.

Other work under way includes development of large booster rockets, air-to-air missiles and plastic cases for solid-propellant rockets.

The Joclin Manufacturing Co.
Lufbery Ave.,
Wallingford, Conn.

Positions will need to be filled in all departments, particularly in development and sales. Salary ranges and employe benefits are comparable with the most progressive in industry. Particularly important is the growth curve of the company which has tripled in the past two years and promises to continue at this rate for at least the next five years.

Boeing Airplane Co.
Pilotless Aircraft Div.
Seattle, Wash.

This company foresees a continuation of the trend toward increasing the proportion of procurement funds which are spent for missiles as compared to aircraft. Employment in missile work will continue to increase. Boeing expects its Pilotless Aircraft Division to double in size within the next five years. Right now—in line with most of the rest of the industry—Boeing is not hiring any except highly skilled people in specific job areas. This is a situation which probably will change rapidly.

It is company policy to advance a man according to his ability and accomplishments. Boeing has established comprehensive programs for graduate study, scholarship awards, a voluntary training schedule and a management development program.

An invention incentive plan and a suggestion award system are two ways an employe can earn big bonus dollars. If the patent is granted, the employe receives an additional payment plus 20% of any royalties received. Individual awards have gone as high as $11,500.

A large majority of employes subscribe to the Group Life Insurance plan. Boeing offers the best available medical, surgical and hospital coverage to fit the needs of the employe in each area.★

Time grows short for meeting

The Red Education Challenge

by Dr. Albert Parry
Colgate University

TECHNICAL EDUCATION in the Soviet Union starts early and is thorough.

Until 1955, Soviet children spent 30 per cent of the first four years of schooling on science. In the next three to six years they spent 46 per cent of their time on science. Currently, time devoted to science study has been upped to 53 per cent.

In the 10-year Soviet school, from the ages of seven to 17, all students have to take 10 years of mathematics; five years of biology; five years of physics; four years of chemistry; and one year of astronomy.

They begin the study of biology at the age of 10; algebra, geometry and physics at 12; chemistry at 13; trigonometry, calculus and astronomy at 16.

During a typical recent year (1955) less than one-third of our high school graduates had taken a year of chemistry, about one-fourth had had a year of physics, and only one graduate out of 15 had taken advanced mathematics.

Rigors of the College Level

In a number of our high schools, some of the exact sciences are not available even for those boys and girls who may want them.

Although most of our high schools offer a general science course, it is considerably watered down compared with the solid training Russian youngsters get. And at that, only a little more than one-fifth of our American students take that feeble course.

Soviet secondary-school students receive about five times more hours in science and mathematics than the minimum required for entrance by a high-caliber American college.

So good is the technical-scientific preparation of a Soviet student that at the end of his 10-year schooling he knows more than an American science major at the end of 13 years of schooling.

On the college level a Russian student spends 27 per cent of his time in general science and 67 per cent in his field of specialization. The remaining six per cent is devoted to the study of Marxism-Leninism (which, incidentally, used to have a more important part in the curriculum, but has yielded in recent years to science).

Soviet engineering schools require five and one-half years of study compared with the American four-year college program. While our engineering colleges give our student 3700 to 4000 instruction hours in 22 to 25 subjects before graduating him, Soviet engineering schools cram the student with 5200 to 5500 instruction hours in 35 to 40 individual subjects.

As in their middle and lower schools, their college and university classes meet six days a week. The Russian school year on all levels is 10 months long, not eight as in our colleges.

In the Soviet Union foreign languages are taught primarily to enable budding Soviet engineers and scientists to read engineering and scientific literature in those languages.

The study of a foreign language is compulsory in Soviet schools. A student is started at the age of 11. By the time he graduates from a secondary school at the age of 17 he has had six years of either English, German or French. Forty per cent of all primary and secondary-school students and two-thirds of Soviet college students take English.

Only 14 per cent of all our public school students study a foreign language. Only about 10 U.S. high schools or preparatory schools teach Russian and only a handful of the students at these schools take Russian. The situation is not too much better in our colleges and universities—less than 200 of them teach Russian. The classes are small and the dropout rate of such courses is high.

Advanced Training and Research

There are only 33 universities in the Soviet Union, but, unlike ours, these schools do not concentrate on liberal arts. Instead, they emphasize advanced scientific training.

In addition, there are some 800 specialized colleges or "institutes" as the Russians call them. Of this impressive number, 177 are engineering institutes covering every conceivable field and specialty.

A typical engineering college, such as the Novocherkassk Polytechnical Institute in the Don River region, graduates 1100 to 1200 specialists of several kinds annually. The Kalinin Polytechnical Institute in Leningrad alone graduates more than 500 metallurgical engineers each year compared with some 660 metallurgists graduated by all our American colleges together.

Last spring all Soviet colleges graduated a total of 265,000 technical specialists, of whom 80,000 were engineers, or two and one-half times as many as we did. Our total annual engineering graduates number 32,000.

A great deal of Russia's top-level research is done at the Academy of Sciences and its numerous institutes. These have comparatively few students, presumably the best of each year's crop culled from the general run of colleges. But the country's outstanding savants are usually attached to the Academy's institutes where they are given well-equipped laboratories, ample staffs and any other necessary equipment.

Tuition on all levels of Soviet schooling is free, and in addition college students who excel are rewarded with scholarships and fellowships. A college student who gets mostly "A" grades and only a few "B"s is given such a scholarship, but with the very first "C" this monetary aid ceases.

While not sumptuous, such assistance enables the student to finish his courses without working on the side. Very few Soviet students ever take any side jobs. But in the summer they either serve as apprentices in their future professions or help with the crops in Western Siberia and North Kazakhstan as "volunteers."

Straight "A" records bring with them higher scholarships. The more advanced and specialized a student, the more of a stipend he receives from the Soviet state. Similarly, among Soviet professors, the more learned an ex-

pert, the more salary and extras he gets. Full professors in the USSR are paid 16 times the average laborer's wage. In the United States a full professor gets only two and one-half times the average laborer's wage.

The Coin's Reverse Side

The Soviet 10-year schools are not as prevalent as would appear from their propaganda. The Moscow government says that such schools will be universal in the USSR by 1960. Right now seven-year schools are far more general, while 10-year schools are found mainly in cities and in only a few rural areas. Only 15 per cent of all Soviet children complete those 10-year schools.

Graduation from a 10-year school does not guarantee a chance to go to college. Only one out of every 12 applicants to Russia's better engineering schools and the science departments of her universities is accepted. Nor does the Soviet government feel it has enough other college facilities for all those young men and women who want a higher education.

There is now an all-out government campaign in Russia to convince the nation's youth that they can be useful and happy without going to college, that for many of them lifelong careers as mechanics, plain workers or collective milkmaids can also be very satisfying. Much dissatisfaction and restlessness among the USSR's lower-strata youth can now be noted, traceable among other things to this exclusion from higher schooling and better careers.

Only some 30 per cent of those now graduating from Russia's 10-year schools go to colleges and universities. Others, both seven-year and 10-year school graduates (the vast majority of Soviet youth and girls), are directed to secondary technical schools, to manual-training schools (called "labor-reserve" schools) or straight to low-paid factory and farm jobs.

The "Privilegentsia"

Complaints are heard increasingly in the Soviet Union that sons and daughters of important Communists such as political bosses, well-heeled managers and engineers, army marshals and generals and navy admirals get undeserved good grades in schools, that they gain college entrance while gifted children of lower classes and poorer families have to quit school after the seventh or 10th year at age 14 or 17. There are stories of the rich and powerful bribing school directors and examiners. Some such complaints find their way into the Soviet press.

The charge frequently is made by the Russians themselves that much Soviet training in secondary and high schools is theory only, resulting in little practical knowledge, chiefly because both teachers and pupils have new "upper-class" reluctance to dirty their hands on machinery. On one occasion KOMSOMOLSKAYA PRAVDA wrote bitterly: "Some graduates boast of their 'deep' knowledge of physics, yet don't know how to change a burned fuse."

Inefficiency of teachers and laziness of students are another theme of lament. In a letter to the editor of LITERATURNAYA GAZETA, two professors of a teachers' college near Moscow charged that much foreign language study in Soviet schools is nominal only because of this inefficiency and laziness: "Secondary-school students complete their education with very weak knowledge in this field. Also, many specialists graduating from colleges know foreign languages poorly."

Only six out of every 10 Russians who go to college graduate, and of these (the criticism is made), not all deserve their diplomas.

On graduating from college, young Russians are given five days to rest up and pack before they are sent off to jobs which they have to stay with for a minimum of three years. A picked handful from each graduating class are kept at school for advanced postgraduate study as *aspiranty* for a candidate's degree, the equivalent of our master's degree or slightly higher. Eventually a few may become doctors of philosophy.

There is an intermittent wail in the Soviet press that some of these "chosen few" are picked not for their talents or efforts but because of their fathers' pull. Another frequent complaint is that graduates assigned to jobs in the provinces use their families' influence to have the assignments changed. They want to remain in Moscow and other large cities, amid the bright lights and comforts that go with the bureaucratic or technocratic privileges of their parents.

That the Soviets are ahead of us in certain very important phases of rocketry is all too evident now. But this does not mean that, because of their educational system, they are ahead of us in every field of science and engineering. Even the statistics on the number of Soviet specialists, now cited as proof of overall Russian superiority over us, may be misleading.

In our figures of American engineers and technicians graduated annually, we do not usually include the vast numbers of workers and foremen trained on their jobs to handle machinery. But these are the skills for which the Soviet authorities often issue special diplomas or certificates. We do not. Much Soviet training is in schools, not on the job, as is our practice. This makes a difference in the statistics of skilled "graduates."

Our farmers can drive and fix tractors without needing diplomas and are not counted in our rolls of school-trained "specialists." Nor do we give diplomas to those who can mix the right feed or medicine for farm animals. But in Russia, tractor drivers and mechanics are in a definite "skilled" category, and so are "higher-grade" cattle tenders, called zootekhniki.

It is true that in our country not enough effort, time, money and manpower go into basic research. In some fields of research the Soviets handle things differently and better.

However, on his recent return from a visit to Russian laboratories, one of our scientists, Dr. Donald J. Hughes of the Brookhaven National Laboratory in Long Island, reported surprising gaps in Soviet atomic research.

This suggests that while pouring the best of their basic research forces into one field—rocketry—the Russians disregard certain other vital branches of science and technology.

Propaganda Aspects Important

The most crucial deficiency in Soviet education, however, is the fact that it produces narrow experts lacking well-rounded knowledge and understanding of the world around them.

The Kremlin gives its young training that is technical and scientific, a thorough and often excellent education in blueprints and machinery, but instead of liberal arts it feeds them propaganda, in lieu of humanities it tries to imbue them with hatred for humanity.

A young Russian who defected to us once said:

"The Soviets want people to be brilliant in their field, but nonthinking insofar as politics and propaganda are concerned. When they succeed in creating a brilliant man who cannot think, they will have achieved their ideal society."

As we meet the Soviet challenge by changing certain aspects of our mass education, we must take care not to repeat the bad Soviet error of swamping young minds with technology to the exclusion of everything else. Our spirit of broad inquiry and of freedom in quest must be preserved. Such is the other challenge of Soviet education which also must be met if we are to survive as truly free men and women.★

Minuteman to Missileman

by Capt. George T. Cahill, Jr.
U.S. Army Air Defense Command

SINCE THE HISTORIC era of the Minuteman, the increasingly impersonal aspect of warfare has presented a problem in regard to manpower procurement for the Armed Forces. The National Guard and the Reserves have probably more closely approached the hometown defense appeal and purpose as exemplified by the Minuteman. In wartime the National Guard and Reserves fight away from home whenever the tactical situation dictates.

In early 1954, Army antiaircraft artillery guided missile sites began to supplement, and in some instances replace, antiaircraft gun sites around our great metropolitan and strategic defense areas. The number of these sites is increasing monthly. During the past year alone, the number of *Nike* battalions has increased by 51 per cent.

The sites, stretching from coast to coast, are under the direct operational control of the Army Air Defense Command (ARADCOM) with headquarters at Colorado Springs, Colo., and comprise the Army element of a joint headquarters known as the North American Air Defense Command (NORAD). The Army Air Defense Command is led by Lt. Gen. Charles E. Hart, a veteran of more than 33 years artillery experience.

Establishment of missile sites within metropolitan areas has created daily community relations problems on a scale seldom encountered by the armed services. The Army and the Army Air Defense Command use every available medium to create and maintain harmonious community relations and to educate the public to the necessity for antiaircraft guns and guided missiles being situated in their communities.

Early this year, an announcement of tremendous significance to the American public was made by former Secretary of Defense Charles E. Wilson. He divulged that *Nike-Hercules* will be capable of being armed with an atomic warhead. This will enable a single missile to knock down entire fleets of enemy aircraft and certain guided misiles.

It is now a fact that the atomic package will be stored in proximity to communities throughout the country for immediate use. The Department of Defense has explained that accident danger from nuclear air bursts is practically nonexistent. The answer is relatively simple and based on common sense: missile bursts will occur at such high altitudes that no injury will be inflicted on those on the ground.

In some instances, when *Nike* began to appear in public parks and the suburban areas, considerable opposition was expressed by the local citizenry. Fear of the unknown initially alarmed the property owners near *Nike* sites.

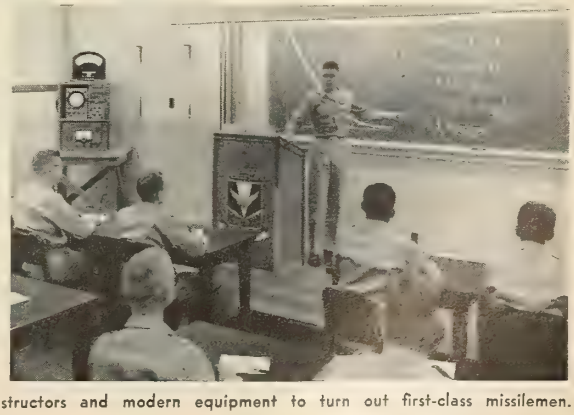
But due to the fine spirit of cooperation by the majority of the news media outlets and the admirable work accomplished within the communities by young *Nike* battery commanders, initial opposition has been overcome.

It's difficult to visualize the deadly *Nike* in beautifully landscaped surroundings. Yet, the Army has deliberately encouraged this incongruous setting for the *Nike* by carrying on an extensive and continuing site-beautification program. Local property owners and real estate brokers were reassured when beautification of the sites blended the batteries into the communities in which they are located.

Extensive safety precautions make the *Nike* missile exceptionally safe to handle. Underground storage facilities, and the fact that *Nike* is not capable of detonation until fired, increases the safety margin. Once *Nike* is fired during an actual aerial invasion, any malfunction will automatically detonate the missile in midair. Each site has a standard supply of missiles, and is ready to fire in a matter of seconds. It has been said that a *Nike* site is less dangerous to the community than the local gas station.

Nike is never fired from permanent sites during practice alerts.





Schools like this at Fort Bliss, Texas, use modern facilities, top-notch instructors and modern equipment to turn out first-class missilemen.

Instead, every *Nike* crew in the country attends and competes in practice firing once each year at Red Canyon Range Camp, N.M. Here, the Missilemen maintain proficiency by firing live *Nike* missiles at jet drone planes and by theoretical firing at actual Air Force bombers.

With all the headlines about superweapons, we frequently lose sight of the men who create and use them. Without a driver, an automobile is a useless inanimate object. Man is indispensable and his degree of skill is an intimate correlate to the effectiveness of the weapon.

The days of drafting unskilled and uneducated men into the services is rapidly becoming a matter of history. It ended before the conclusion of the Korean War a scant four years ago. Today's army must be comprised of well-educated, fast, alert thinkers able to act and reason for themselves.

In recognition of the tremendous strides made by industry in wage scales and welfare programs for its employees during the past 20 years, the Department of Defense continues to press Congress for legislation which will increase the attractiveness of a military career. Much favorable legislation has been enacted and still more is pending. However, to date, the severe inconveniences encountered by the soldier are not compensated at a rate commensurate with that of his civilian counterpart.

Frequent assertion is made from within and without the services that the military must compete with industry for skilled manpower; that industry is stealing, outright, technicians trained by the services. To a degree, that is true. However, the situation must be looked at objectively.

Both the services and industry are striving toward the same goal—development of the best possible weapons to be utilized in the defense of this nation. By the same token, the military must not be deprived of the ability to employ these weapons effectively.

Procurement and retention of personnel with potential to absorb the highly technical and specialized training necessary to man complex weapons is a challenge which merits the attention of the top manpower procurement officials of the Army.

As previously emphasized, a weapon, even in this age of hydrogen bombs and electronic brains, is never so self-sufficient that it does not require the direction and guidance of trained electronics specialists. Because of the tremendous outlay of government monies for the procurement of highly developed radar and other electronics equipment, it is imperative that the personnel recruited for assignment to the Army Air Defense Command be of the highest caliber obtainable from the manpower resources of the nation.

The thousands of dollars it costs the taxpayer to train a *Nike* specialist includes work with the latest type equipment and from 38 to 42 weeks of instruction at the Army Antiaircraft Artillery and Guided Missile Center, Fort Bliss, Tex. It adds up to an invaluable technical education.

In the spring of 1956, Charles E. Wilson appointed a committee to study the servicewide problem of skilled personnel retention. This committee, officially designated the Department of Defense Advisory Committee on Professional and Technical Compensation, is referred to as the Cordiner Committee, after its chairman, Ralph J. Cordiner, president of General Electric.

The program proposed by the committee recommends far-reaching legislative and administrative actions for the revision of pay grades to permit additional remuneration for jobs requiring combat leadership and technical, scientific and management ability.

In the meantime, the Army is doing everything possible to create incentives to attract high-caliber youths and, above all, to retain those already in the Army.

Harking back to the day of the Minuteman, who protected his own community, the Army Air Defense Command is striving to develop a recruitment program which is based on the same principle of hometown service.



Photogenic, deadly NIKE-AJAX is examined.

Since its inception in January 1956, through this program alone, more than 12,000 volunteers have entered the Army Air Defense Command for service with missile units. This influx, still in progress, includes many experienced noncommissioned officers bringing into the command leadership qualities vital to the accomplishment of any task, military or civilian. A group of these noncommissioned officers had been serving elsewhere in the Army in career fields.

The results of this type of procurement have proved so gratifying that plans are now under study to permit choice of assignment for nonprior-service personnel.

Young men enlisted under this program will be accepted for a minimum of three years in the Regular Army. This will provide longer retention of trained Missilemen and minimize the present rapid turnover of trained personnel in *Nike* batteries. Each enlistment will save the Government and taxpayers considerable money.

By having men from the local communities serving at *Nike* sites, community relations should be maintained on the highest level attainable. News media and the public as a whole should have a more comprehensive idea of the purpose, mission and problems confronting the *Nike* units in their communities.

The Army Air Defense Command is ready for the sound of the bell signifying the opening round of hostilities, a bell it devoutly hopes will never ring. Her highly trained *Nike* crews, proudly wearing the red shield-shaped *Nike-Ajax* patch, stand alert 24 hours of every day to unleash their destruction against the foe should this become necessary.

ARADCOM, with its *Nike* and other surface-to-air weapons teamed with its sister air defense forces—the sleek jet interceptors of the Air Force, Navy and Marines, the Navy radar picket ships, the Ground Observer Corps and the National Guard—serves grim warning to potential aggressors bent on the invasion by air of the United States.

The Marquis of Queensberry rules will go out the window at the start of the fray. To achieve the knockout, anything goes. Man of the day will be the modern Minuteman—the Missileman. ★

US-USSR Educational Systems—a Comparison

by William P. Lear

Chairman of the Board, Lear, Inc.

MOST PEOPLE are prone to look down on and underestimate the intelligence of persons whose political faith is at variance with their own. Due to this attitude we get a fairly good idea of how the average American is likely to regard the technical and scientific progress of research in the Soviet Union.

Again, most people in this country are apt to look on our plethora of modern conveniences, such as automatic electrical appliances, radio and television, automobiles, etc., as indicative of scientific progress. They feel this is an indication of our ability to cope better than anybody else with the problems of modern science, including the building of satellites and space ships. We are apt to regard our cherished system of "higher" education for everybody as the correct climate for achieving a dominant position in science and technology.

We cannot evaluate the scientific standing of Soviet Russia against a background of political prejudice and mass-produced comfort. Rather, it behooves us to appraise objectively the Soviet scientific progress during the last several years.

Nothing significant transpired in the USSR during the first decade after the revolution (1919-1927). The condition of the sciences in Russia was very bad since industry was nonexistent. Therefore, they decided to direct their first effort toward science and to make it self-supporting.

About 1927 many Russian scientists working as a gigantic team initiated a project of study which by 1939 had developed into a new science—nonlinear mechanics.

What was surprising, on closer scrutiny of this stupendous work, was the extraordinary harmonious cooperation between the different specialties—pure mathematicians developed new methods which were inspired from engineering developments, while physicists and engineers were dealing freely in the most abstract branches of mathematics, etc.

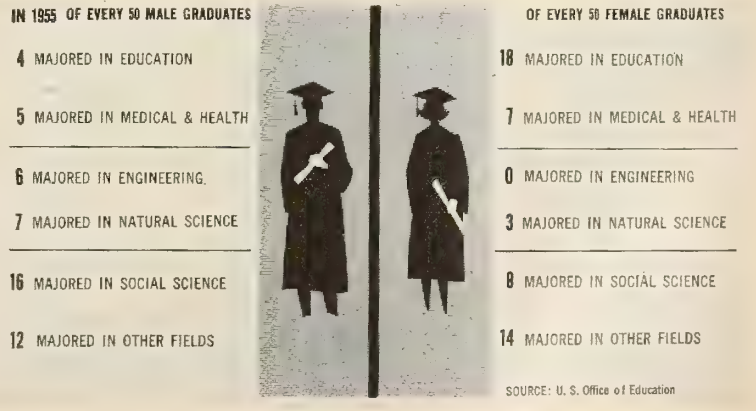
It is unbelievable that such a gigantic project (four institutes in Moscow, Leningrad, Kiev and Gorky working jointly) was started without any definite objectives. It created a new science which ultimately opened entirely new horizons in almost every direction—electricity, mechanics, electronics, astronomy, biology and econometrics.

How much is there that we do not know about Russian development? Perhaps here is the real reason for occasional surprises, such as when we hear about developments in guided missiles, artificial satellites, etc.

In our democracies, developments like these are likely only in wartime, but in the USSR such organizations work continuously. It is no wonder that scientific developments are reported from the USSR far ahead of our estimated schedule.

This error in judgment very likely arises from the fact that we measure things in terms of the industrial development in the United States. In this respect we are far ahead of the USSR. But this yardstick is hardly applicable inasmuch as in new discoveries the scientific accomplishments are far more important than developments in industry. Also, a highly synchronized and well-coordinated work of a number of well-equipped laboratories, through war and peace, can produce spectacular results simply because the question of money does not come up in a country in which the standard of living is so low. The lack of industry (on the U.S. scale) may be a very adverse factor when mass production is required.

At present there are 306 journals published by perhaps 30 to 40 various



institutes under the supreme direction of the USSR Academy of Sciences. The Academy is unique in that it directs the whole scientific activity of the country —from H bombs, transcontinental missiles, and satellites to growing tomatoes above the Arctic Circle, breeding of animals, etc.

One gets the impression that the number of scientists in the USSR is far greater than here, a fact which has been discussed many times in recent years. In Russia the children are followed up very closely and vocational selection operates very efficiently. If a child shows interest, say, in mathematics, he is pushed systematically in this direction and if he shows good results all expenses are paid by the State. If one takes into account that there is no other outlet than the Government service, it is no wonder that there are so many young scientists of the very first order.

Whether the system is good or bad politically is another story, but as far as the supply of good scientists is concerned, the system of "vocational guidance" and subsequent free training seems to work well, judging from the results achieved during the last three decades.

The present technical superiority of the Soviets is, in my opinion, not accidental, but was bound to happen as a consequence of their superior system of higher technical education.

To enter institutions of higher learning in Russia, as well as in most of the European countries, the individual has to pass very stiff tests to prove that he is entitled to professional treatment. Obviously, such a system weeds out the mediocre ones, before they have a chance to crowd into the universities and drag down the quality of teaching to a level commensurate with their own limited intellect. By setting these rigid standards for the right to pursue higher education, the Soviet has built up a body of engineers and scientists, capable of outstanding achievements.

Slowly and inexorably the Russian system of higher education has overcome the tremendous handicaps imposed on it by the revolution and has now caught up with us, if not surpassed us, in the military sciences.

As a corollary, let us now take a look at the American educational system, and see how it compares with the Russian.

First of all, let us consider our high school education. To attend high school seems to have become the inalienable right of every American youth, regardless of whether or not he has the will and the mental powers to absorb higher learning. As a result, the curricula of the high schools are, with a few exceptions, adjusted to be commensurate with the average level of student intelligence and, perhaps, in order not to impose too much restraint on their extracurricular activities.

Mediocrity and mental impotency are nursed along to the detriment and depreciation of an intelligent minority that should, and will some day, be the leaders in their chosen fields. Therefore, your embryonic scientist enters the university with about two years deficiency in basic education, as compared to the Russian high school student.

He now also faces the task of learning to think independently, which had not been part of his high school curriculum, probably because of the inconvenience this would have imposed on the minds of the greater number of students. Many of his instructors are uninspiring, and have not much more to offer than the text book they are following.

There are, of course, many exceptions in this respect, but, as a rule, the quality and depth of learning among our college and university teachers is greatly below the standards of their European counterparts. *Low salaries* and the *general lack of esteem* in which college professors are generally held in this country are undoubtedly contributing factors in this respect.

And, as in the high school, we find also in the college the tendency, although not to the same extent, to adjust the level and pace of the instruction to suit the slow march of the average intellect.

This state of affairs is literally suicidal in an era in which the survival of a nation depends on its intellectual forces, rather than on its armed might.

If we pursue the present system of higher education, the consequences will, ultimately, be disastrous for this nation.

Some expert opinion holds that the United States ran the risk of losing the last war (World War II), because of a general lack of competency in the fundamental sciences. The production of weapons rather than the superiority of weapons gave us the victory. We won that war, not because of our scientific level, but in spite of it.

Our development of the atomic bomb was an outstanding technological achievement, but without the European educated scientists, such as Einstein, Bohr, Von Neumann, Fermi and Gamow, just to mention a few, the result would probably have been fizzle instead of fission.

We cannot hope to maintain a comparable level of scientific achievement as long as we persist in using the same mold to shape the mind of the future scientists as that of the future clerk, salesman, storekeeper, and what not.

It should be obvious to intelligent and right-thinking Americans that we must revamp our system of higher education to seek out and give special training to those who offer the best chance to insure our supremacy in scientific thought and development.

First, we must reorganize our high school system so as to separate the boys from the men. At the end of an eight-year elementary school, common to everybody, a separation must be effected on the basis of aptitude and intelligence tests.

Those who pass certain minimum requirements should then, provided they wish to do so, be transferred to what we may call preparatory school, while those who don't pass the tests, or don't wish to go in for higher education, would be transferred to a high school of very much the same make-up as at present. The present four-year course should be compressed into a three-year course and more emphasis be laid on vocational training.

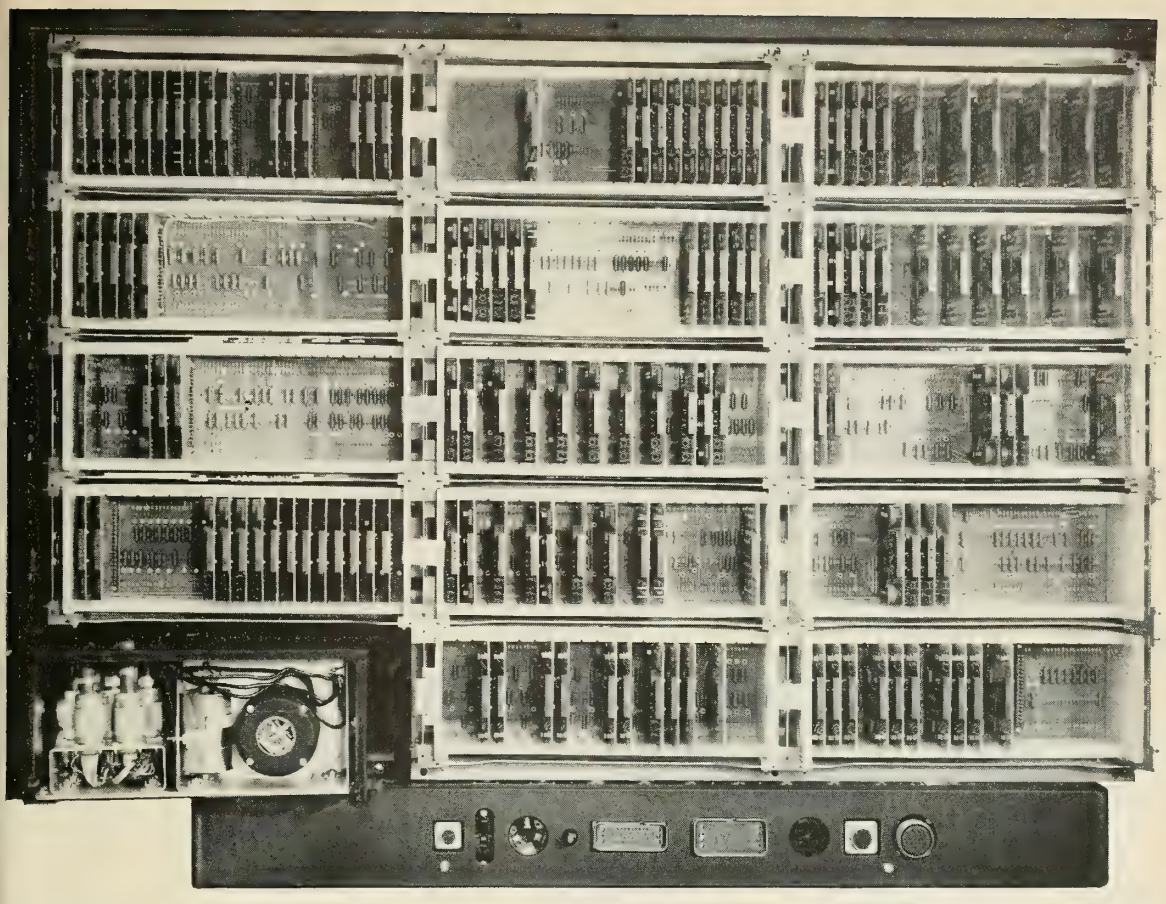
The curriculum of the preparatory school may conveniently be split along two major lines which we may term the modern line and the classical line.

In the modern line, designed to accommodate those who intend to pursue studies in the natural sciences and engineering, the emphasis should be on mathematics, physics, chemistry, German and Russian. The classical line should be designed to further the interests of those who wish to become physicians, lawyers, teachers, etc., with the emphasis on such subjects as philosophy, literature, history, English, French and, perhaps, Latin. The teachers in these preparatory schools should all have advanced college degrees, be adequately compensated, and have a genuine interest in education and the dissemination of knowledge.

Next, we will have to raise the standards of teaching in our universities in order to exploit to the fullest the much higher intelligence and basic knowledge of those coming from the preparatory school. In cases where the cost of university study is beyond the means of the student, and provided his scholastic record warrants it, the Government should advance the necessary funds in the interest of the nation.

Most people will say that these changes in our higher education are extreme but so are the times in which we live.

We must acknowledge that unless we first lay a broad foundation for scientific development, the resulting structure will be limited in height. One cannot build a skyscraper on the foundation for a one-story house.★



The Role of
PRODUCT ENGINEERING
in Systems Work

It has become characteristic of modern weapons systems that they are required to operate under severe environmental conditions, as well as to meet stringent weight and space limitations. Moreover, the complexity of many of these systems poses additional difficult reliability problems, while at the same time the increasingly critical consequences that depend on the proper functioning of the typical system logically call for a *higher* degree of reliability than previously achieved. The same is true of certain electronic systems for industrial applications, such as the Ramo-Wooldridge digital control computer, some of whose design features are shown above.

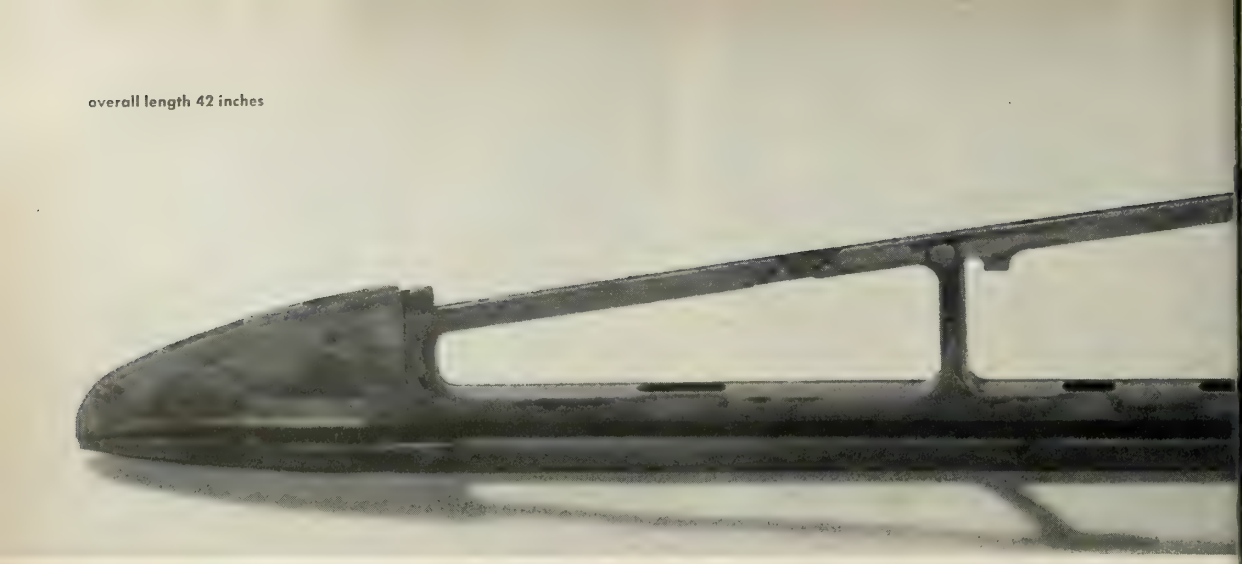
Meeting all of these requirements is in large part the responsibility of product engineering. Generally speaking, product engineering starts with a system or subsystem at the breadboard stage and transforms it into the final product, which in addition to meeting all of the requirements previously stated, must be practical to manufacture and to maintain. Such creative productizing requires the development of ingenious mechanical design features, a thorough knowledge of circuit design and component reliability, and a broad familiarity with materials and manufacturing processes.

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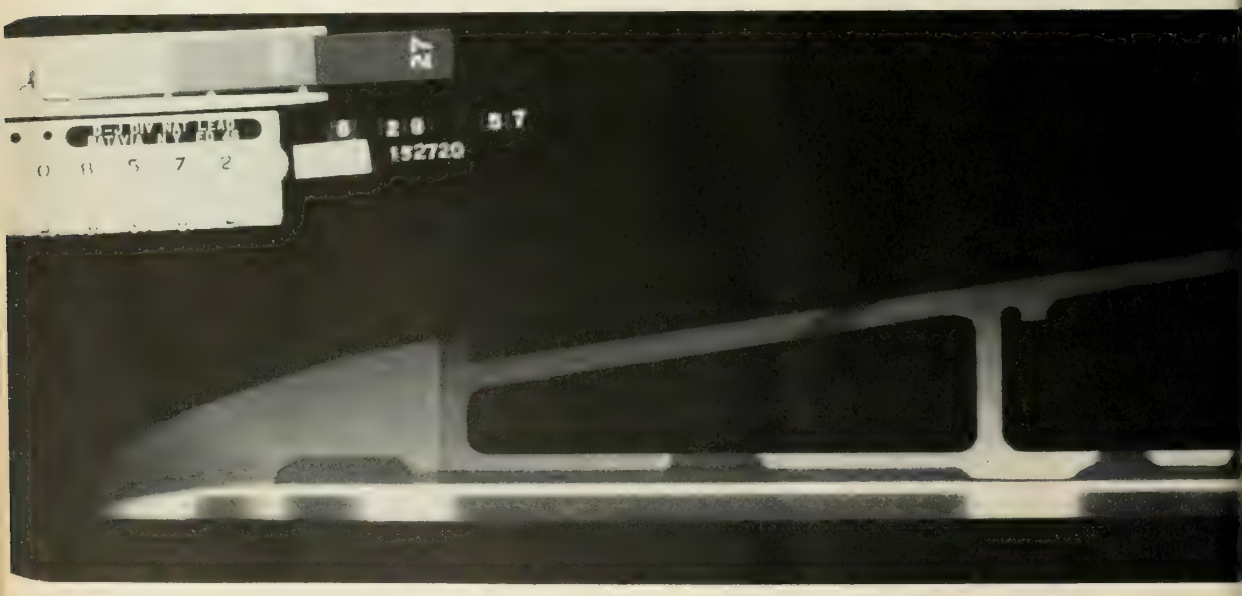
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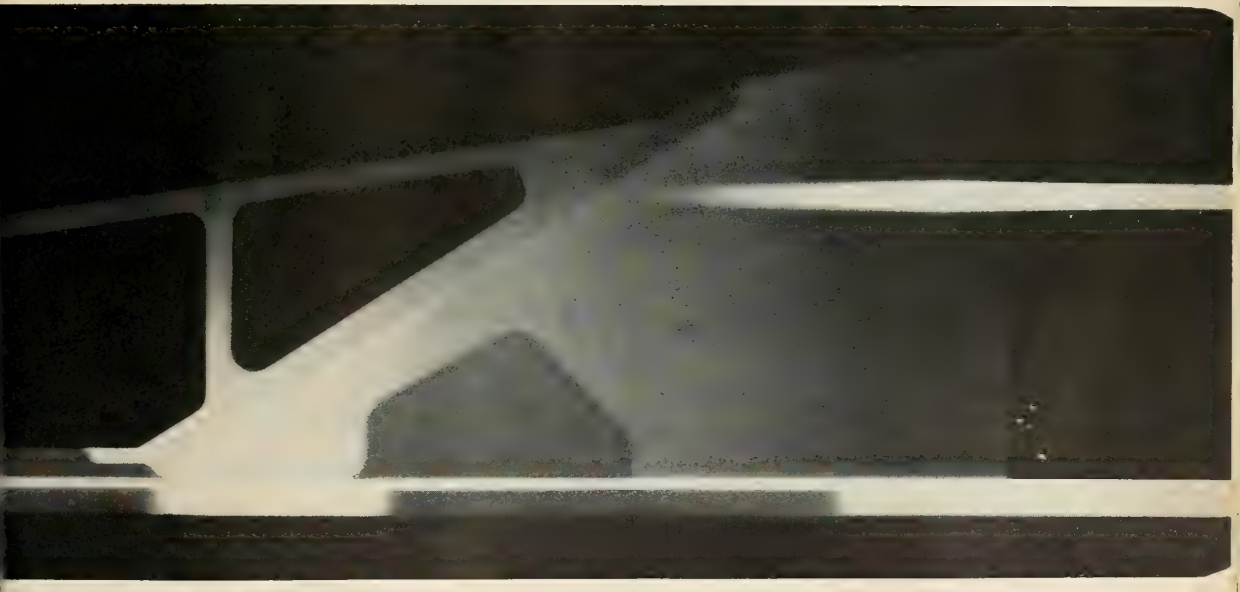
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f primary-aircraft-structural* quality



ıeir uniformity and soundness

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many developments in die casting, this one started with stomer's need . . . Hughes Aircraft's.

ey, and the Armed Services, needed such castings. The s *might* be made other ways. But at what cost! What sacri- n weight — and materials! If it *could* be die cast, if there a magnesium alloy able to stand supersonic air stresses . . . took a while. But, with close cooperation from engineers th Doehler-Jarvis and Hughes, the way was found.

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*A primary aircraft structural is a major load-bearing component member any single failure of which would result in loss of the aircraft.

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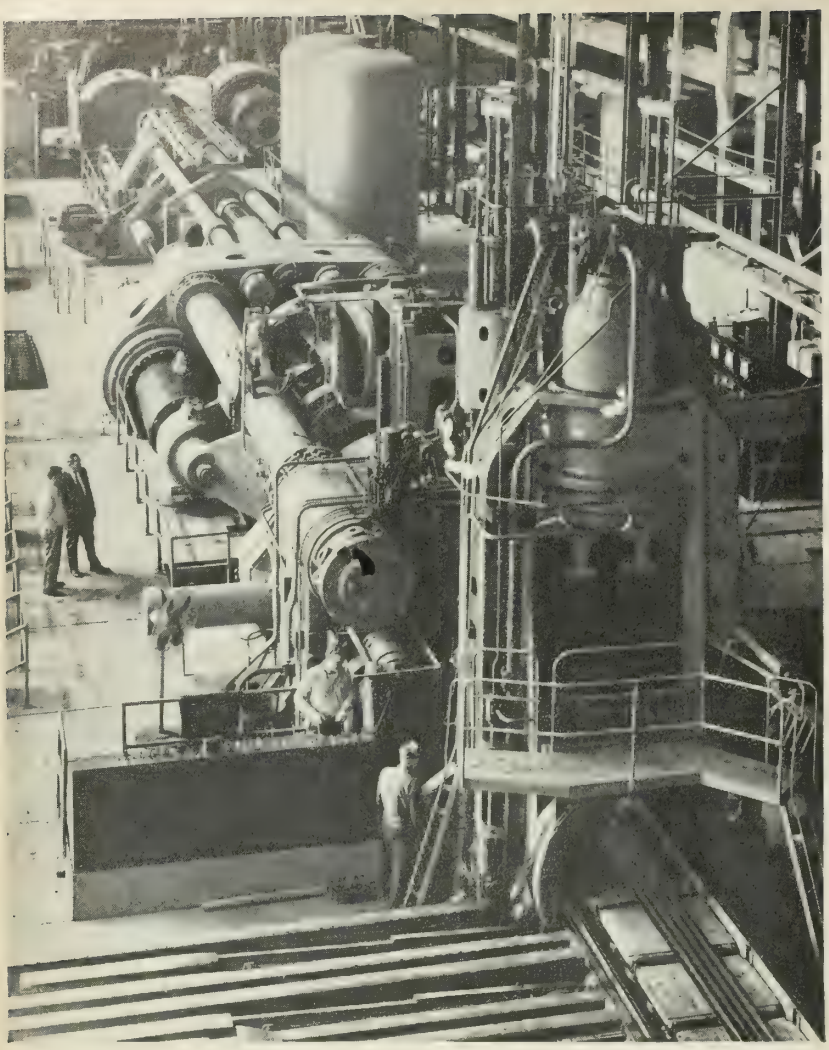
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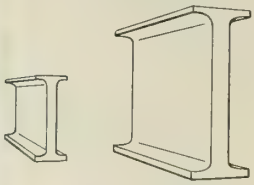
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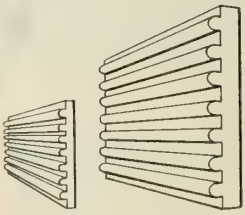


HOW THE 13,200-TON PRESS BOOSTS EXTRUSION CAPACITY



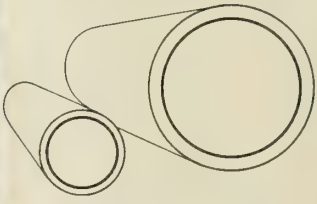
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Propulsion Engineering

by Alfred J. Zaehringer



FREE RADICAL WORK is underway at Catholic University. Hydrazoic acid has been thermally decomposed to give the NH radical or its polymer, which is a stable, blue paramagnetic solid at liquid nitrogen temperatures. No success has yet been reported in finding a solvent for the free radical, which is among the most stable yet known. Most other free radicals are unstable even at temperatures near absolute zero. Scientists at the Washington, D.C., university have also prepared the dimethylamino radical which reacts to form tetramethyl hydrazine.

FLUORINE COMPOUNDS AVAILABLE for propellant investigators are elemental fluorine, halogen fluorides, nitrogen trifluoride, oxygen difluoride and perchloryl fluoride.

BORON REACTIONS: Iowa State University chemists have decomposed diborane in an inert atmosphere under silent discharge to yield 40% B_4H_{10}, 20% B_5H_9, 30% B_5H_{11}, small amounts of B_6H_{10} and an unknown hydride with nine boron atoms per molecule. The work was sponsored by Callery Chemical. Burning rate of boron metal rods was reported by Experiment, Inc. At 15 psi, the rate is about 2 cm/min and the burning surface temperature was estimated at 2040°C. Rensselaer Polytechnic and Eastman Kodak have teamed up to study the explosive oxidation of pentaborane. Surfaces coated with oxidation products act as catalysts and broaden the explosive-limit range. Carbon monoxide and iron carbonyl inhibit the reaction.

BLOWOUT VELOCITY FOR BORON HYDRIDES IS HIGH. Under same conditions of combustion, NACA illustrates that ethylene combustion with flameholder will blowout at about 47 ft/sec while diborane will go well over 100 ft/sec, without flameout. This means ramjets using boron fuels could cruise at much higher altitudes than with conventional hydrocarbon fuels.

PLENTY OF LITHIUM. Foote Mineral Co. estimates the concentration of lithium in the earth's crust at $4x10^{-3}$%, or about as abundant as lead or six times as plentiful as tin. The company calculates that the reaction of lithium and fluorine could give an I_{sp} of 336 sec and 318 for lithium and oxygen. Lithium hydride is also suggested as a superfuel. Lithium perchlorate also figures high since, on a volume basis, there is 29% more oxygen in $LiClO_4$ at room temperature than in liquid oxygen at the boiling point. It looks like Foote Mineral will team up with Hooker Electrochemical (Niagara Falls, N.Y.) to produce lithium perchlorate by a *direct* electrolytic method. Cost could come way down. This might make it competitive with ammonium perchlorate. Hooker is looking over a site at Montague, Mich., for the plant.

LONG-BURNING SOLID-PROPELLANT MOTORS are in the works. Jet Propulsion Laboratory is working on a water-cooled nozzle for a large solid-propellant rocket motor.

EXISTING SOLIDS WILL BE BOOSTED by three new developments. One firm has built and flown a solid motor that is 97% propellant. Hopes to hit 98% in another six months. Studies going on indicate that burning rates can be jacked up by a factor of 10 without pressure increase. On the other hand, there is one proposal out for operation of combustion pressures of 250,000 psi!

TETRANITROMETHANE IS BACK. Small-scale pilot plant manufacture is underway again. Oxidant or monopropellants would be the logical application

LOX FOR REDSTONE: Army has shown its 4-trailer, mobile, 20 tons/day LOX plant. The low-pressure unit (100 psi) was built by Air Products, Inc. and cost is $1 million. The product is 99.5% pure and the plant can operate at temperatures of −25° to 125°F. It takes one pound of diesel fuel to grind out two pounds of LOX. The four units are for intake, compression, heat exchange and separation.

ORIOLE . . .

a really low-cost research missile



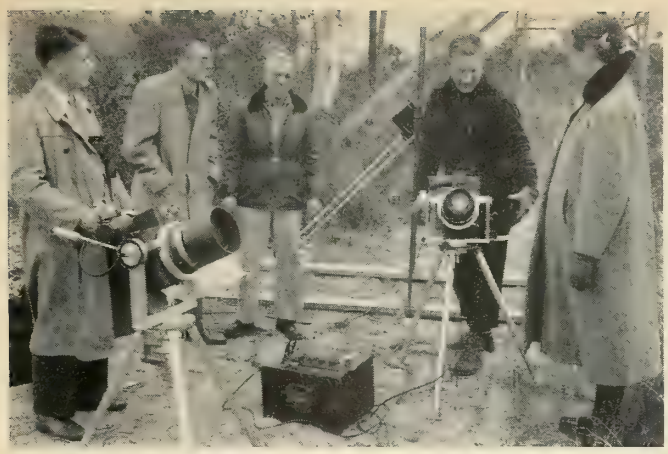




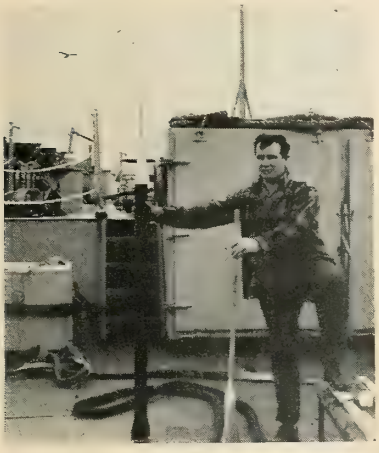
Men learn by doing, and by learning they produce for the good of all men. On this page you see the various steps involved in the assembly for launching of the ORIOLE, a recently proved high-altitude research rocket developed by the University of Maryland and costing less than $300 per copy—except for the booster, a surplus LOKI, which is free. This sting can carry scientific payload to an altitude of 80 or 120 miles, depending solely on its diameter. It has no motor of its own but relies only on its LOKI booster. The ORIOLE sting completely lacks either fins or flare, thus reducing drag to a minimum. It achieves aerodynamic stability because its center of gravity is placed very far forward. The sting lets go from the booster immediately after it has completed its 0.8-second burning time.







Actual designer of the ORIOLE is Richard Bettinger, shown on these pages in the plaid shirt. A graduate student at Maryland, he works under the direction of Astrophysicist Dr. S. Fred Singer (in sports cap). These pictures were taken off Cape Charles, Va., aboard the U.S.S. Launcher where the ORIOLE was successfully tested. Shot to the left shows one of two mosquito-infested ground stations. ORIOLE is fired in a conventional TERRAPIN launcher—shown in the shots right below. Development of the ORIOLE solves one major problem facing U.S. universities—the availability of a simple, low-cast research rocket. Next, a series of readily available launching sites is needed so that students can launch their rockets more or less at will. If it were not for the full cooperation of Navy, Army and Air Force, ORIOLE would still be waiting for its first test.











High-energy George P. Sutton

Backstage with the New ARS President, Booster of Scientific Education

by Erica Cromley

IF THE NEW American Rocket Society president has his way, America will move quickly to close the gap on Russia's impressive output of scientists and engineers.

George P. Sutton, 37, who takes over the ARS reins this month, feels strongly that the government should set up a committee to recommend steps which would: (1) attract more students into scientific and engineering training, (2) expand the number of courses available, (3) raise the quality of available courses, (4) encourage graduates to continue postgraduate studies and (5) raise the level and number of competent instructors.

"It is extremely important that we roll up our sleeves and tackle the problem at the foundation—the schools," he says.

A key scientist in Rocketdyne's early design of the nation's first high-thrust, large rocket engines, Sutton has made prolific contributions to technical education. His book, ROCKET PROPULSION ELEMENTS, standard text in many technical colleges, has been termed *The Book* for rocketry training by many of the country's top missile experts. The Russians were impressed with it too, published a USSR edition, and sent Sutton a free copy.

Throughout the 15 years of his brilliant career Sutton has taken time out to write many technical magazine articles. In 1951 he received the G. Edward Pendray award of the ARS for his outstanding contributions to the literature of jet propulsion.

The current chief of preliminary design for Rocketdyne fell into the rocket business "somewhat by accident," after scuttling a boyhood dream of becoming a doctor.

It happened during a job interview at Aerojet. He was told only that the "highly classified" work involved thermodynamics and hydraulics. Sutton figured he'd be working on hydraulic and heating equipment for aircraft. He accepted and inadvertently began a career in rocketry which has brought him worldwide recognition.

He did have one brief and unexpected fling at his first love—medicine—when he assisted an impatient stork. While working his way through Cal Tech as maintenance engineer at a city hospital, a hurried call for help brought him racing across the street to the hospital's parking lot, which is as close as a new mother got to the delivery room. He used a laboratory clamp ("nonsterilized," says Sutton) to bind the squalling newcomer's umbilical cord and wrapped him in his lab jacket ("also nonsterilized").

As in doctors' families, the Suttons are reconciled to periodic fatherless homelife. Sometimes Mrs. Yvonne Sutton wonders whether she wouldn't see more of him if he had gone into medicine. He is frequently called on





Left—George assists daughters Marilyn (left) and Christine in the study of astronomy. Right—George, Marilyn and Yvonne study the sky.

to lecture and is away from home on about 10 week-long trips each year.

Because he now travels so much, the Suttons are not as active in community affairs as they had been, preferring to spend as much time as possible in family activities. They are, however, active in the Woodland Hills, Calif. community band to which daughter Marilyn, 10, contributes her clarinet-playing talents. There's a band at home, too. Mrs. Sutton plays the marimba, Pa Sutton is the accordianist, Christine, 12, is pianist while Marilyn tootles.

"It took us a year and a half before we could play together so it sounded like anything," Mrs. Sutton laughs. "But we're real 'cool' now." Lately, Henshaw Street, Woodland Hills has been jumping to the strains of "True Love" and "Tammy", favorite numbers of the Sutton Swing Quartet.

Life with this scientist is seldom dull. Mrs. S. recalls a recent evening when they came home from a party, at one a.m., grabbed the telescope and went out on the lawn to check the positions of the stars. Then they set the alarm for four a.m., and with bathrobes flying, rechecked them. Before they settled back to bed for good Mrs. S. recounts, "George looked up his astronomy book to make sure the stars were where they were supposed to be. He was very pleased to find they were."

The Sutton family agree on one family project each year. This year it's Operation "Skywatch" with a German telescope bought during the rocket experts recent International Astronautics Federation meeting in Barcelona. Last year, it was Operation "Mountain Climbing." The Suttons are skiers and plan one ski vacation each year without the children.



High-energy George P. Sutton

Mrs. S. describes her spouse as "clear-thinking, concise and able to sum up any issue quickly to a sound conclusion." He has two pet peeves: lack of organization and weeding the garden.

"He's easy to work with and a bug on waltzes," says Rocketdyne's Assistant Chief Engineer Paul Vogt. "Once he jarred the car pool by waltzing the car down an empty street in time to a Strauss waltz coming in over the radio."

In his "spare time" Sutton keeps abreast of things by reading avidly: m/r, *Business Week, Time, Reader's Digest* and ARS publications.

Sutton began his career in rocketry in 1943, after graduation from California Institute of Technology with a Master of Science degree in mechanical engineering. His earlier studies included an Associate of Arts degree in mechanical engineering from Cal Tech in 1942. Today he continues advanced studies in several fields.

Sutton joined a nucleus group of North American Aviation guided missile scientists in 1946 as a research engineer. He subsequently has held successive prominent roles in that group's development of high-thrust rocket propulsion systems and has been the chief of Rocketdyne's preliminary design section since 1953.

He has served on the faculties for Mechanical Engineering at the California Institute of Technology, the University of Southern California and the University of California at Los Angeles.

Among his current contributions to science is his active participation on the Nomenclature Subcommittee of the American Standards Association. The group has developed the first nationally accepted standard symbols and terms for rocket propulsion.

Sutton is a founder and the first president of the Southern California Section of the American Rocket Society and currently is a national director of the society. He has served three years as a director of the society, as Chairman of its National Membership Committee, and Awards Committee. He is the 1957 Vice President and has been nominated for ARS president in 1958. He also is a member of the American Society of Mechanical Engineers, the Institute of Aeronautical Sciences, the British Interplanetary Society and Deutsche Gesellschaft für Raketentechnik und Raumfahrt (the German Rocket Society).★



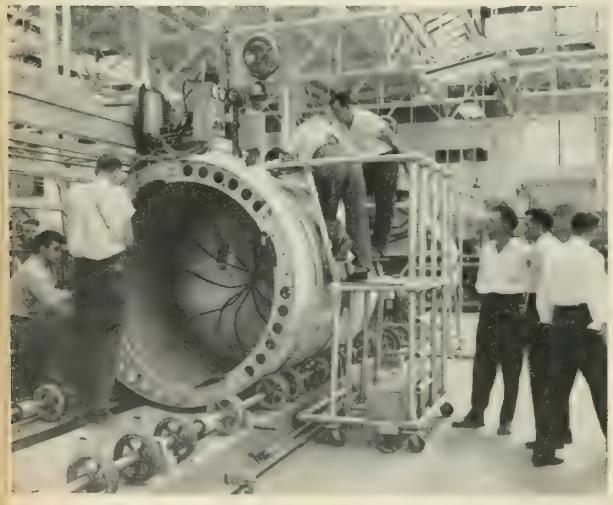


Left—The Suttons enjoy an evening at home with the family pet. Right—The Sutton Swing Quartet demonstrates its "cool" talents.

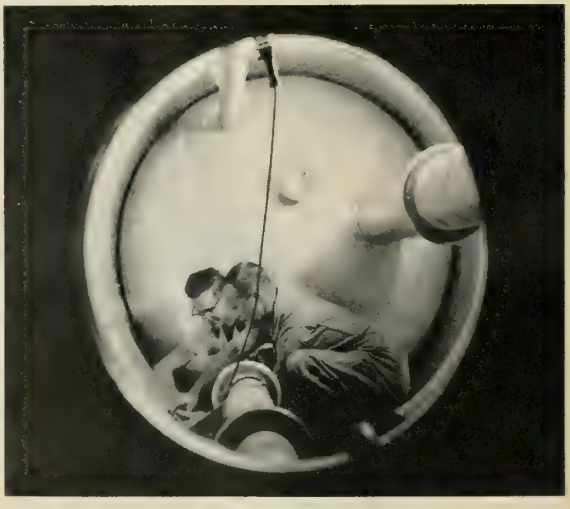


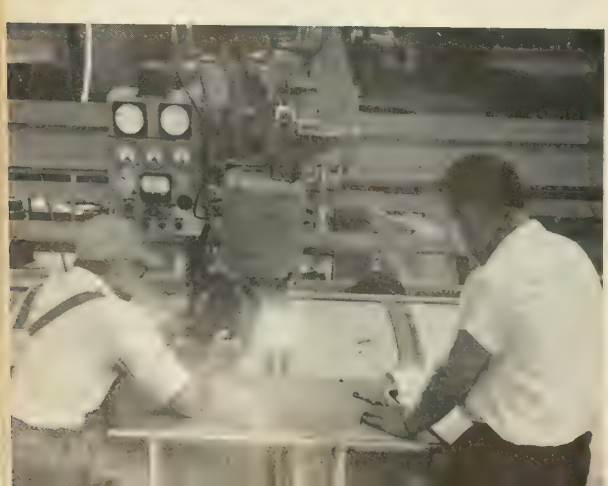
Fabricating the REDSTONE

Reynolds Metals Co. has been fabricating and assembling REDSTONE missile fuselages at its Sheffield, Ala. plant since 1952. The plant fabricates the nose, fuel body, rocket-engine housing and tail fins, and assembles the complete fuselage. Engines, guidance systems and controls are installed elsewhere by Rocketdyne, Ford Instrument Co., Chrysler and ABMA. Left—A horizontal mill cuts sections of the missile fuselage to length.



The JUPITER IRBM is also being fabricated and assembled at the Sheffield plant. Sheet material for the REDSTONE is from McCook and Listerhill, tubing from Phoenix, stampings from Louisville Plant 12. The advanced nature of the program demands a high degree of skill from the engineers and production men. Currently, more than 200 people are employed at the plant. Left—Body sections are welded together on automatic welding machine.

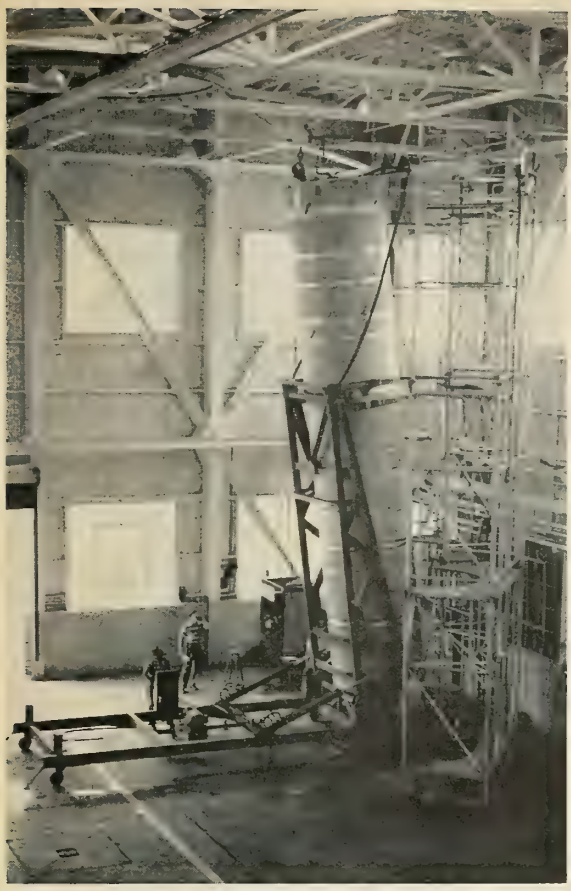


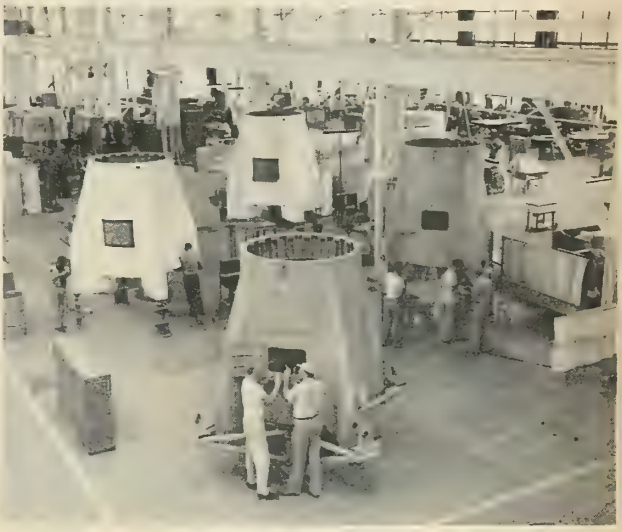


Exacting quality control techniques are employed throughout the entire fabricating operation. All welds are X-rayed and each component is protected constantly from dirt or damage. Above—Through a port opening at the aft end of one of the missiles, two employees are shown inside the fuel tank installing fuel and wire conduits. Left—View of welding machine in operation. After the joint has been completely welded a radiographer inspects the bead.

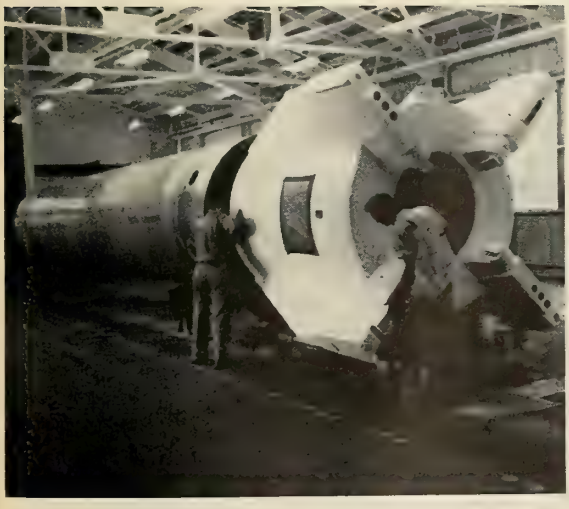
missile production

The REDSTONE is assembled into three major component parts, one consisting of the rocket engine and fin section, one, the tank section and the other, the control-system and warhead section. Control and warhead section is approximately 29 ft. in length, the tank section 24 ft. and the engine housing 10 ft. Left —A tank section of the body is raised into position for a hydrostatic test. Water, under pressure, is used to check for leaks.

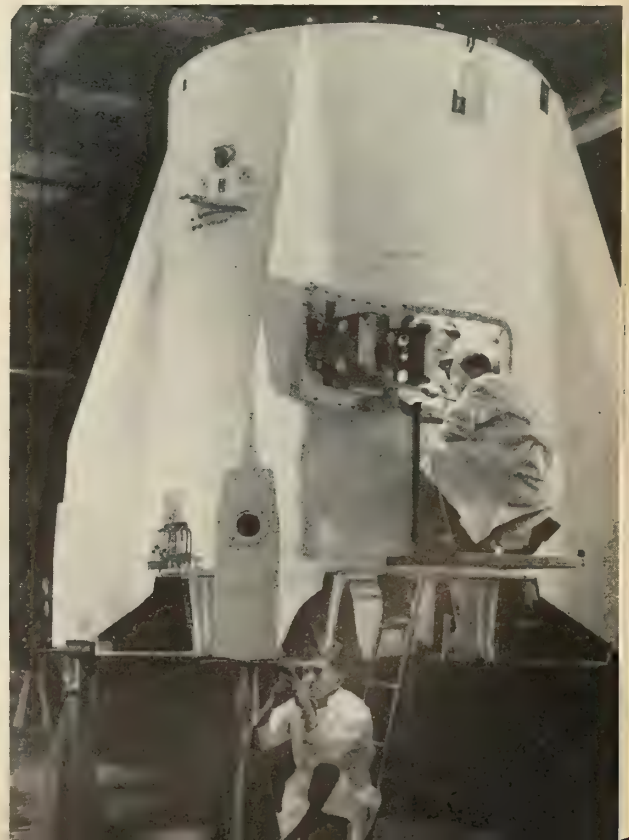




The ruggedness of the REDSTONE is apparent in these photos of the rocket-engine housing and fins. It is controlled in flight by graphite vanes attached to the fins and protruding into the exhaust stream of the rocket. Above—Tail sections of the missile in various stages of assembly at the Reynolds Sheffield plant.



The REDSTONE is rapidly becoming the workhorse of the infant space age. Its role as the first stage for the three-stage JUPITER-C research rocket and the recent decision to put the JUPITER-C into the satellite service have made the REDSTONE's task extremely vital. Above—Reynolds workmen wheel a tail section into place behind the center section. Right—Chrysler workers install mechanisms in missile tail section after delivery by Reynolds.



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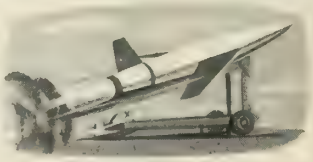
Greer's important contribution in the guided missile field includes major work on the Bomarc, Redstone, Talos, Terrier and Thor. Greer has provided systems and components for these operational and experimental missiles since the inception of the program.

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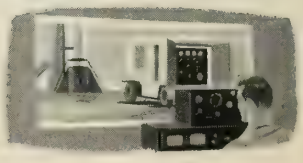
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Missile Age Machining

by A. B. Albrecht
Monarch Machine Tool Co.

BECAUSE so sizeable a portion of our production efforts is not devoted to the machining of missile, rocket and jet components, rapid engineering advances in materials and designs have challenged manufacturers to produce precision parts on short notice for use in development models. In addition, these manufacturers have had to supply reliable and interchangeable parts for rocket powerplants and missiles already in service.

To meet these vital defense needs on a competitive basis has required the use of the most modern contouring equipment, along with good machining practice. The Monarch air-gage tracer lathe is an example of the type of tracer-controlled precision contouring machine that has been found best suited to the needs of missile and rocket contractors.

The services of resourceful and diversified manufacturers in producing missile components has contributed greatly to our nation's defense programs. However, a major factor in the ability of these manufacturers to produce lies in the development work and the advances which have come from the machine tool industry.

"Until they start building square rockets, an engine lathe of 48-inch, or more, swing plus air-gage tracer equipment for precision contour control will still be the tool most needed in the production of guided missiles." These were the words of a man who has been intimately associated with the business of producing rocket hardware practically from the outset of our nation's program of missile development. He is head of a concern which currently has contracts for machining parts for over 15 major missiles.

We already have available in our current tracer lathe designs most of the features that missile machining experts are finding essential for this exacting type of metal removal. This involves not only complex contours and ultraclose tolerances, but critical surface finishes as well. The machines are precision-built engine lathes featuring a sensitive duplicating device, called the air-gage tracer, which automatically controls contour turning, facing and boring cuts using a single-point tool.

Most components for rockets and missiles now in production, or in the advanced development stage, demand extensive machining and the application of special techniques in the contouring of complex shapes from rough forgings. Common materials are A-286, Inconel, 17-7 Stainless and heat-treated AISI-4130.

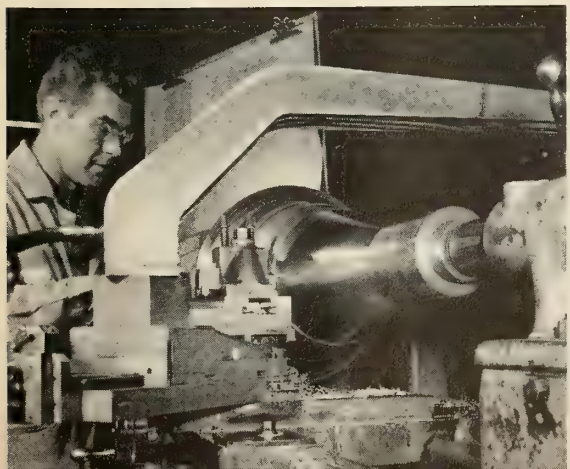
Because a missile is subjected to extensive stress under flight conditions, quality and reliability of finished components are vital considerations. Design often compels the use of materials up to their ultimate strength. This necessitates close control of machining operations so as to obtain a finished part dimensionally stable and free from residual stresses. Continued close quality control is required to meet military specifications.

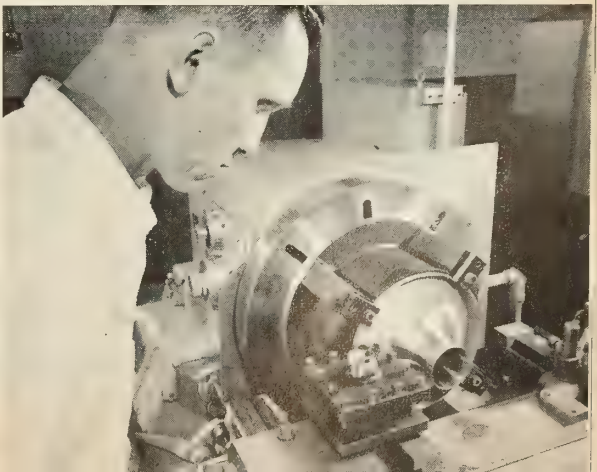
The troublesome machining problems in the missile field stem primarily from the required turning of larger parts of varied contour and extremely thin wall sections. A part 30 to 60 inches in diameter with a wall thickness of 0.076 to 0.187 inch is not uncommon. The initial forging is often a solid blank and considerable metal must be removed in producing the desired contour.

Machining Practice

Machining techniques, already well established in turning jet aircraft parts from high temperature superalloys, have been effectively applied in the missile field. At Steel Products Engineering Co., for example, turbine discs for the J-79 engine are turned on right angle lathes to close tolerances, using constant surface cutting speed. A 23-microinch finish is obtained on the A-286 alloy on the finish pass. Cutting speeds of 275 fpm are used for both the roughing and finishing operations. This method is currently used by Steel Products Engineering to produce smaller parts for a missile ramjet. Grinding is eliminated, and stress re-

Representative air-gage tracer-lathe controlled machining operations. Lathes are (left) 20-inch Series 61 and Series 62 (right).





lieving after machining is unnecessary.

A major contractor in the field of missile hardware, Diversey Engineering Co., has utilized the maximum versatility of the air-gage tracer lathe in producing parts for prototypes, as well as for production programs. Nozzles, bulkheads, rings, adapters, etc., are all entirely contour turned on Monarch equipment. Exacting complex contours are obtained with the swivel slide in a single machining set-up. Tracer pressure against the template is light, thereby eliminating template wear which ensures a high degree of accuracy.

Accurate template reproduction assures built-in inspection on complex contours which would otherwise require costly gaging fixtures.

Major components for rocket motors by Reaction, Thiokol, and Aerojet General must be completely machined to a 63-microinch finish or better. Because of the complexity of these and other missile parts, grinding such shapes would be costly and difficult, if not impossible. Thus, final finish is entirely dependent on the performance of the air-gage tracer, the nature of the tooling, and the properties of the material. On heat-treated and age-hardened materials a 20- to 26-microinch finish is easily obtained on these lathes with carbide tooling.

Many smaller shops, such as United Aero Products, have shared in the responsibility of producing components for development models to meet engineering test schedules. Tracer templates can be changed quickly from one job to another, and design changes can be made directly on the flat template, thus eliminating costly delays for later production orders on difficult parts.

A new application for the air-gage tracer lathe has been in the area of machining large, thin-walled, nonmetallic parts. Fabricated components, such as nozzle liners produced by Haveg Industries, all require finish machining to close tolerances so that they properly blend the contour into the metal section in which they are mounted. These temperature-resistant materials are somewhat abrasive and are normally turned at reduced cutting speeds, using light feeds and harder tungsten grade carbides.

Tooling Practice

In practice, contouring of today's missile parts normally starts with the roughing out of the basic forging on heavy duty lathes. This involves the removal of one-half to three-quarter-inch stock on a side. The roughed blank is then given a thorough hardening or solution treatment under strict metallurgical control.

Material requirements vary, but the most common alloys currently used are AISI-4130 and C-1020 steel. The specified hardness for alloy steels after heat treatment normally is R_c 32/36. Solution-treated, high-temperature alloys are machined in the range of 300-360 Brinell. In this hardness range, these alloys are very abrasive and difficult to turn. Finish turning is accomplished with K7H carbide, using light feeds and surface speeds of 200 to 280 fpm.

A knowledge of the properties and machinability of the material is a major requirement in machining the many new metals used in the missile field. Specific cutting speeds and feeds are required for each alloy. Some plastics and nonferrous alloys may be machined at high speeds; while the superalloys, including titanium, plutonium, 17-7Ph, and Niomic, all require cutting speeds under 100 fpm. A new addition to the above group is heat-treated tool steels in the range of R_c 42/56.

General turning practice involves selecting the proper cutting speed, which is determined by the machinability of the alloy, and then balancing the feed rate in relationship to the rigidity of the workpiece and capacity of the machine. Finishing cuts are sometimes limited by thin wall sections and by the extreme hardness of the material. Roughing feeds generally range from 0.010 to 0.016 ipr. Finishing feeds depend on the finish requirements and the tendency for chatter to occur. The high-temperature alloys require the use of positive rake tools with minimum nose radius, and show more tendency to work harden. The depth of cut on finishing normally is held below 0.040-inch.

Monarch is prepared to offer tracer-controlled lathes of greater swing as the needs of missile manufacturers ultimately increase. However, our newest design of lathes now offers many of the features which machining experts are finding essential for this exacting type of metal removal.

In addition, we and other machine tool manufacturers are carrying on considerable research on the machining of new alloys and on developing new contouring techniques. Basic metal cutting studies have already shown the correct cutting conditions and tool geometry for profiling critical parts.

Engineering and demonstration facilities are available to help contracting firms obtain a working knowledge in the contour machining of metals. Combining good machining practice with air-gage tracer equipment results in one of the most important teams in our rocket and missile program.★



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By Norman L. Baker

Manned Re-entry: A Technical Barrier of the Past?

While *Laika, Sputnik* II's space passenger, was still alive and orbiting the earth several hours after launching, the world asked: will the dog be returned to earth, and if so, how?

It was this concern over *Sputnik's* passenger that spotlighted the tremendous advances that have been made by industry and government research centers in the field of missile re-entry research. Representatives of two companies engaged in re-entry research were unshakably convinced that the present advances in the state of the art made it feasible to return *Laika* to the earth alive.

The advances are basically the result of ballistic missile nose cone re-entry research. The announcement that the Army had solved the re-entry problem by returning to the earth intact the nose cone of a *Jupiter-C* test rocket was the first report of this breakthrough.

Two distinct but basically similar approaches have been employed by the Army and the Air Force.

The Army nose cone used a combination of devices many of which were for the sole purpose of retrieving the cone from the ocean. Cook Electric Co. of Skokie, Ill., developed a parachute-drag device for reducing the re-entry velocity. Device was either a series of rip-away parachutes, increasing in size as velocity was reduced, or a single parachute controlled in resistance area by a reefer apparatus that released the parachute as a function of velocity and drag.

The nose cone was manufactured by Cooper Development as a machined stainless steel unit. This was covered with a Rockide ceramic coating by Norton Abrasives.

Avco, engaged in Air Force nose cone research, may be employing the parachute technique, but unlike the Army technique, the "parachute" utilizes steel for overcoming high temperatures.

For example, a satellite weighing 250 pounds (the approximate weight of the *Sputnik* II payload) could be returned safely with a stainless-steel drag area of approximately 500 square feet. By opening the parachute at the satellite's perigee—say 150 miles—the payload would return to the earth in about 15 orbits. Inhabited vehicle deceleration must be held below nine g's.

General Electric has been employing the drag-brake principle for deceleration, orientation and separation of the "live" portion of the nose cone. Basic difference in the techniques apparently is the velocity of re-entry. Avco and Cook techniques indicate subsonic velocities while the GE approach would probably be high supersonic.

A. J. Eggers of NACO has proposed a satellite-recovery technique with a ceramic-coated hemispherical satellite of 10-feet diameter that would enter the atmosphere and decelerate at less than eight g's. Satellite weight would be in the neighborhood of *Sputnik* II or approximately 1200 pounds. After subsonic velocities had been reached, parachutes would lower the satellite to the earth.

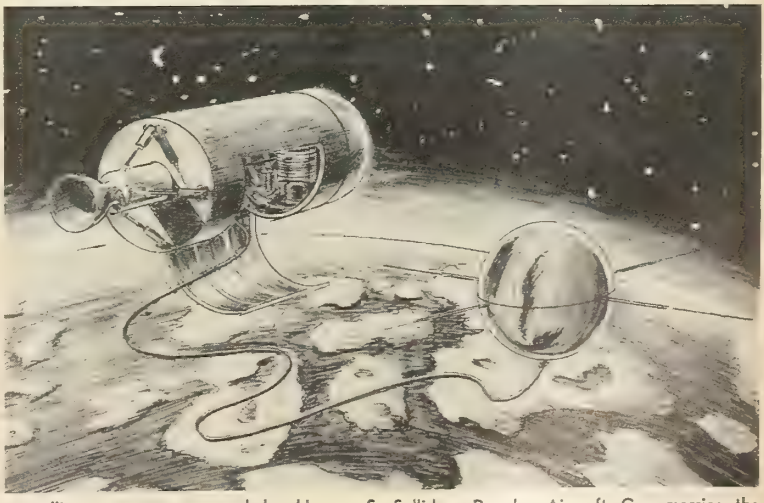
Two other firms actively engaged in re-entry research are the Arnold Engineering Development Center and the Lockheed missile systems division. Both employ far-hypersonic shock tubes for model "flight" tests.

A satellite recovery proposal by Horace S. Solliday of Douglas Aircraft Co. is a representative engineering approach to the problem. Solliday's design would use the third-stage launching rocket as the initial re-entry phase vehicle. The satellite would be ejected from the rocket for making scientific measurements while joined to the rocket by a cable. Later, the satellite is winched in and the rocket oriented for retrofiring the engine for deceleration.

The orientation and retrofiring of the rocket would be a very complex and difficult operation for an unmanned satellite. In addition, 50-80 per cent of total weight to be decelerated would be needed as rocket fuel.

The rocket, which would have an ICBM-type nose cone, would again be turned around and exposed to the high-temperature shock layer. After ribbon chute speed is reached the satellite would again be ejected, this time by explosive action, to enable it to penetrate the supersonic slip stream. Finally, by ejecting a series of increasing-diameter parachutes, the payload would be lowered to the earth undamaged.

Russia announced the solving of the re-entry problem by using "sweating walls" and a form of ceramics called "metallo-ceramics." Composition is silicon and 10 to 20 per cent cobalt powder.



A satellite recovery proposal by Horace S. Solliday, Douglas Aircraft Co., marries the satellite and final-stage rocket for launch, scientific measurements and during re-entry.

Mach 17 Shock Tube Tests *Polaris* Design

A 13,000 mph shock tube for testing ballistic missile design is in operation at the Lockheed missile systems division research and development labs at Palo Alto, Calif. The 40-foot-long tube is being used for advanced design work on the *Polaris* flat ballistic missile.

The tube, made of stainless steel, has an inside diameter of three inches and walls an inch and a half thick. Two separate techniques will be employed in the tube to produce shock waves. One will be the use of high-pressure helium. The other will be the use of a mixture of hydrogen and oxygen, which will be triggered into explosion by a spark.

The shock tube works on the build-up of gas under pressure at one end of the tube which ruptures a thin diaphragm when the pressure reaches a certain level. The high-pressure gas then speeds down the tube behind a hypersonic shock wave.

Lockheed scientists will study heat transfer, shock wave shapes and other details of airflow around missile models. In addition they will perform basic research in high temperature gas dynamics.

Lockheed is the missile system manager of the *Polaris*, a solid-propellant weapon to be launched from submarines, and provides technical direction to several other firms working on the program.

Martin Creates *Vanguard-Titan* Division

The Martin Co., has formed a new division for speed up of the on-the-spot arrangements for launching both *Vanguard* and the Air Force *Titan* ICBM.

G. T. Willey, the company's corporate vice president-manufacturing, will assume additional duties as vice president and general manager of the new division. This division will have equal status with Martin's Baltimore, Denver, and Orlando divisions. He will have charge of all Martin activities in the Patrick Air Force Base and Cape Canaveral area, including the continued testing of latest versions of the *Matador* surface-to-surface missile.

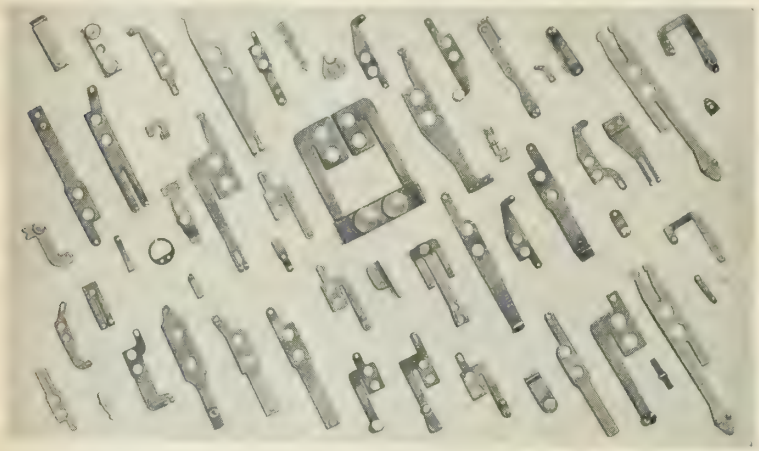
Martin's *Titan* project, involving a contract in the amount of $358 million for the second of two mutually supporting Air Force ICBM programs, got under way early in 1956 with construction of the company's Denver division near Denver, Col.

Ceramic Radomes Designed for Re-entry

Gladding, McBean & Co., has just completed the first ten prototype high-alumina ceramic radomes designed to withstand the high temperatures generated when ballistic missiles re-enter the atmosphere.

First, many formidable obstacles had to be overcome. The major difficulty lies in the fact that a radome must be as transparent as possible to radar waves. This meant finding a material that would have the right electrical properties as well as the required temperature resistance and strength. More important, it meant devising a manufacturing method which could hold the wall thickness to a tolerance of 0.001 inch.

The technique finally worked out by Gladding, McBean starts with high purity alumina (Al_2O_3) with which is mixed a small amount of organic binder to give some strength before firing. This results in a final body of 97 per cent alumina. This is made up in the form of a slurry which is prayed on a chrome-plated steel mandrel with a spray gun. Later fabrication operations subject the radome to a pressure of about 30,000 psi and temperatures of above 3000°F.



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Major *Hawk* Subcontractor Is Northrop Aircraft

Northrop Aircraft holds contracts amounting to approximately $20 million which were awarded by Raytheon for work on the *Hawk* surface-to-air missile sytem. Contracts are for research, development and manufacture of airframe components and support equipment for the *Hawk*, including appropriations for facilities, engineering services and procurement.

Raytheon Manufacturing Co., Andover, Mass., is the prime contractor for Army Ordnance, with Northrop in the position of major subcontractor. Northrop has the responsibility for structural integrity and aerodynamic performance of the missile, design and fabrication of major airframe portions, the mobile launcher, missile loader, pallet and reusable container.

About 70 per cent of the total dollar volume of the Northrop work on the *Hawk* is for support-equipment items such as the integrated launcher and missile loader for field use. The integrated loader-launcher is said to employ an extremely lightweight and compact design concept. It is self-propelled, can ford streams up to 30 inches in depth, and could

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float if required.

Manufacture of portions of the *Hawk* is underway at the company's Anaheim, Calif., facility, while engineering activity is under way at both the Anaheim and Hawthorne facilities.

Specifically designed for defense against low-flying aircraft, the *Hawk* uses a Thiokol solid-propellant rocket motor.

AP&C Production Exceeds Demands

HENDERSON, Nev.—America's only large-scale producer of high-energy ammonium perchlorate is still undergoing the gradual transition toward large, high-performance solid rockets. Virtually all U.S. high-performance solid rockets utilizing composite propellants use ammonium perchlorate as the oxidizer.

The large, Navy-financed, American Potash & Chemical Corp. plant is still operating below its estimated 1200-tons-per-month ammonium perchlorate (AP) capacity.

The plant has had a rough time selling AP. The market was originally small and because of the low production, nobody wanted to swing toward this item. Despite shutdowns, however, the employment figure for the Henderson operations has grown from 75 in 1945 to over 400 at the present time. Present operation theory appears to be, work on the smallest efficient schedule and/or make limited large runs and stockpile.

Orders are still sporadic for AP but the trend for larger solid missiles may at least make the future more certain for AP. As yet, the American AP market for missiles has not been pinched by a competing Norwegian firm.

Atlas Engines In Production At Neosho

Rocketdyne's Neosho, Mo., plant began production last month on engines for the *Atlas* ICBM.

Atlas work at Neosho supplements extensive research and development activities being carried out on the ICBM program at the main plant of Rocketdyne in Canoga Park, Calif., and at its nearby propulsion field.

The recently occupied plant is scheduled to become a prime source for missile propulsion systems during the next year. It has been in build-up production of the developmental engine and components since February. Testing began at its 200-acre field complex early last month.

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West Coast Industry



By Fred S. Hunter

An illuminating example of today's weapons trend is Northrop's report that 57 per cent of its present $216-million backlog is in guided missiles and related equipment. Northrop has two big missile programs in the *Snark* SM-62A and a major subcontract from Raytheon on the Army *Hawk*. Its Radioplane Division also is engaged in development work on a classified Air Force missile weapon system. Pointing out that it has demonstrated its long-range accuracy in numerous successful test flights, Northrop anticipates the *Snark* will continue to occupy a significant position in its weapons roster for several years. Approximately 35 per cent of the company's total work force is engaged in the *Snark* program.

•

Even though it is subsonic (Mach .94), the *Snark* is a more sophisticated bird than many people think, and has a growth element built into it. Its maximum altitude is in the range of 60,000 to 75,000 feet. Performance of its Northrop-designed *Mark* I celestial and inertial guidance system is unimpaired by night or bad weather. It is designed to carry a nuclear or other priority warhead and incorporates a separable nose cone. The company is able to claim that it has "the longest range and the greatest accuracy of any missile in the free world today." The missile, now in production and scheduled to become operational in early 1958, is the "A," but there also are "B" and "C" versions in the program.

•

Delays in settling zoning variances and other details have held up the start of construction on Hughes Aircraft's new $6-million plant for its ground systems division near Fullerton. But the division is functioning in several leased structures, including two located at the Fullerton Airport. Hughes purchased 430 acres of Sunny Hill ranch, a 650-acre tract near Fullerton, for the project. The remaining 220 acres are to be used for a housing subdivision and 20-acre shopping center.

•

President George I. Long reported in San Francisco that Ampex Corp. has revised its projected sales for the fiscal year to April 30 down to $27.5 million from $29.8 million because of the slowdown in defense spending, which, he said, has hit the electronics industry, too. Ampex also sees its September 1 payroll of 2100 cutting back by about 240 by the end of the fiscal year. But for the long pull there will continue to be substantial spending "particularly in the missile area in which we are vitally interested," Long said.

•

We'll make one comment on *Sputnik*, and then subside. There can only be one first. Columbus was such a first. Others followed in bold journeys to America, but who remembers them? The Russians marked up a first with *Sputnik*, and it may very well be in the same historical category as Columbus.

•

Rocketdyne's new film on rocket development history, "Road to the Stars," is about as strong a nontechnical pitch for liquid propellants as it is possible to make. It figures, of course. Rocketdyne is in the business. The film, however, sets high standards.

•

Aerojet-General reports its investment in new facilities in the next year will total $5 million.



Painting by Chesley Bonestell from the book *The Exploration of Mars* by Willy Ley, Wernher Von Braun and Chesley Bonestell, published by Viking Press ($4.95). ©C.B.

How do you control temperature on space ships?

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It would be easy to list here the part Fenwal has played in the ever-progressing field of aircraft temperatures, over-heat detection and other controls. But this would only be repetitious. The aircraft industry is well aware of it.

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Maximum load: 10,500 lbs. on each jack, tension or compression
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Ultimate load: 50,000 lbs. on each jack, tension or compression — 100,000 lbs. total
Military Specs: Assembly designed to meet MIL-M-8609, MIL-A-8064 and MIL-E-5272A
Features: 1. Jacks are equipped with non-jamming stops.
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missile electronics vol. 1, no. 3

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special features

Are radical changes in design concepts necessary to solve reliability problems?

Two engineers who helped design the higher reliability into the Navy's *Terrier* system discuss the problem of reliability design. Russell R. Yost, Jr. and Fred Dreste, of Motorola, Inc., give a clear picture of how quality can be designed into electronic components (page 114).

What is the best method for training personnel to operate high-performance missiles?

Since production-line missiles are not designed for frequent assembly and disassembly by students, they often require extensive overhaul that rivals a new missile in cost. Solution of this problem is the synthetic missile, which is the concept of the Navy's Training Devices Center at Port Washington, New York. J. Gordon Vaeth and Lt. Cmdr. John Huson explain the concept (page 119).

What can we expect of communications systems in outer space?

Recent test vehicles have brought back information about the conditions we can expect to encounter—communication-wise—in space. AAP Electronic Editor Henry Steier gives a run-down on the question in his article on page 121.

cover picture:



This recording optical tracking instrument is being used by the Air Force at Melbourne, Fla., for photographing the flight of missiles fired from Cape Canaveral. It is manufactured by Perkin-Elmer Corp., well-known for its work in this field. Working as part of the overall missile-test-data net, the Melbourne installation will be able to more accurately position missiles than methods previously in use. Controls on the telescope will be adjustable by use of a hand-control stick. The ROTI is complete with its own electronic and mechanical equipment, computers, dark room for film development, maintenance section and air-conditioning system. Automatic correction will be made for parallax and for the earth's curvature. The unit may be operated through remote-control by range personnel, and then operation will be transferred to the ROTI operators when the missile comes into sight.

departments

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MIRACLE IN MINIATURE



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By means of a transistorized circuit and the new RCA half-inch Vidicon, the "Telemite" actually surpasses standard Vidicon-type industrial TV cameras in sensitivity. It produces clear, contrasty pictures with a scene illumination of 10-foot candles or less.

The "Telemite" operates with up to 200 feet of cable between it and the control monitor, and this distance can be further extended by using a repeater amplifier. This is the first TV camera to employ photoelectric sensitivity control, which provides automatic adaptation to widely varying scene illumination.

DEFENSE ELECTRONIC PRODUCTS

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washington briefs



WASHINGTON IS WATCHING THE HANDWRITING ON THE WALL. Many small firms in the electronics industry are experiencing very rough water in the wake of defense cutbacks—*Sputnik* notwithstanding. The administration knows that it is in a jam. There is no question but that many markets for small electronic-specialty firms are drying up. The rise in future defense spending will not come in time to prevent considerable hardship. Aircraft companies, looking for their own business, are cutting the business that keeps many small contractors going.

NEARBY MARTIN CO. WOULD LIQUIDATE and go out of business if peace broke out tomorrow. This statement by Martin's president shows the basic problem now affecting subcontractors tied to companies like Martin. The statement by Martin's president was made in light of the company's total commitment to defense contracts.

THE PENTAGON IS PUSHING THE ICBM DEW LINE PROJECT now being planned by U.S. and Canada. Research studies are under way which will determine the feasibility of such a line. An American-loaned radar has been installed in Saskatchewan and the Pentagon is watching the results of research stemming from use of the radar. It has long been acknowledged that the present DEW line is inadequate for ICBMs.

THE NAVY DEPARTMENT IS IRONING BUGS OUT OF *POLARIS* with use of a new electronic computer capable of "flying" the missile while still on the drawing board. Known as PACE, the computer is being used by Lockheed engineers to eliminate unworkable designs.

DEFENSE DEPARTMENT IS DELUGING THE PRESS with news, any news, about recent rocket developments in the U.S. The latest is an electronic instrument that can analyze an instantaneous sequence of chemical reactions such as take place in the explosion of rocket fuels. Called a "time-of-flight mass spectrometer," the device is being produced by Bendix Aviation Corporation.

ARMY SIGNAL CORPS HAS GREATLY INCREASED RADAR POWER by development of an amplitron tube, which doubles the power efficiency of the magnetron tube presently being used in many radars. This is one of a series of recent steps that considerably boost the usefulness of our radar.

THE AIR FORCE HAS ESTABLISHED unusually high requirements for instrumentation cable, 11 miles of which is now being produced by Rome Cable Corp. for gauging performance of the *Titan* ICBM's rocket engine.

NAVY DEPARTMENT NOTIFIED its major contractors to sharply limit hiring of new employes, except those essential to replace key personnel. The Navy asked that hiring of other employes be cleared by BuAer first.

AIR FORCE'S AIR MATERIEL COMMAND has awarded a contract for "side looking" radar to Texas Instruments, Inc. The system presents a three-dimensional picture of terrain, and a continuous-strip photo is made from the radar scope.

MARTIN'S NEW ELECTRONIC COOLING SYSTEM has impressed Pentagon officials considerably. The system uses water to cool components. The new technique affords an essential constant temperature of components, even though the outside temperature climbs more than a hundred degrees.

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Maximum Collector Voltage (Emitter Open)	100	80	80	60	60	50	50	40	40 volts
Saturation Voltage (13 amp.)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7 volts
Max. Square Wave Power Output at 400 ~ P-P*	400	310	310	225	225	180	180	135	135 watts
Max. Sine Wave Power Output at 400 ~ P-P*	180	140	140	100	100	80	80	60	60 watts
Power Dissipation (Stud Temperature 25°C)	70	70	70	70	55	55	55	55	55 watts
Thermal Gradient from Junction to Mounting Base	1.0°	1.0°	1.0°	1.0°	1.2°	1.2°	1.2°	1.2°	1.2° °C/watt
Nominal Base Current I_B (V_{EC} = —2 volts, I_C = —1.2 amp.)	-19	-19	-19	-13	-24	-13	-24	-13	-27 ma

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Long-range Optics Track Missiles

Photographing a ballistic missile from the time of launch until it is over 100 miles down range is the task of an optical tracking instrument recently installed at Melbourne Beach, Fla. The instrument called ROTI *Mark* II (Recording Optical Tracking Instrument) will soon go into operation as a part of a guided missile data-collection station of the Air Force Missile Test Center tracking net.

ROTI *Mark* II will permit the Air Force to measure the position of a missile moving in space and time with a greater accuracy than has heretofore been possible. The ROTI series of instruments were designed, developed and are being built by the Perkin-Elmer Corp., a leading supplier of such systems. The *Mark* II unit will be used in conjunction with the firings of *Jupiter, Thor, Polaris, Atlas, Titan* long-range ballistic missiles.

The Melbourne Beach ROTI Data Collection Station will operate as an integral part of the Patrick range communication and tracking net. Information from radar and other communication nets will be fed into the station when a missile is fired. Computers at the station will convert this into information that will activate and adjust the ROTI. Corrections will be made automatically for parallax (difference in distance and line of sight from the radar to the station), and for the earth's curvature. ROTI will be focused automatically and will also make automatic corrections as the sky background changes.

The ROTI station can be operated by remote control or by range personnel employing "aided tracking." When operated by range personnel, the same information will be fed into the system. However, when the missile comes within sight, the operators will take over. With aided tracking, the operators need make only the simplest mental calculations and the slightest physical movements to follow the missile. The slightest hand pressure on a stiff-stick control will enable the operator to adjust the acceleration, velocity and position of the telescope.

The ROTI station is a complete, self-sufficient unit, with its own electronic and mechanical equipment, computers, dark room for developing film, maintenance section and air-conditioning system. The tower housing ROTI is very similar to that of an astronomical observatory.

Instruments Analyze Ion Flight Time

A new electronic instrument that can analyze an instantaneous sequence of chemical reactions, such as takes place in explosion of rocket fuels, is in production. The new device, called a "Time-of-Flight Mass Spectrometer," will have numerous applications in the science of missiles and rocketry.

It can complete a chemical analysis in one ten-thousandth of a second, operating on the principle of instantly identifying vaporized gases, liquids and solids (including metals) by revealing their respective molecular masses.

The heart of the new instrument is a four-foot metal vacuum tube that scientists call an "ion gun." Ionized molecules of the elements being analyzed are pulsed like radar signals from one end of the tube to the other and their speed, or "time of flight," is measured electronically and appears as a wave pattern, or spectrum, on an oscilloscope.

Components Reliability Plagues IRBMs, ICBMs

All the fundamental scientific problems for producing long-range ballistic missiles have been solved, Dr. Simon Ramo, executive vice president of the Ramo-Wooldridge Corp. recently announced. He said the major problem of most weapons systems which continues to plague the ballistic mis-

MISSILE TEST DATA TRANSCRIPTION AND ANALYSIS

The transcription, analysis, and evaluation of ballistic missile test data is one of the important aspects of R-W's system engineering and technical direction responsibility for the Air Force Ballistic Missile Program. Utilizing the facilities of R-W's Data Reduction Center, test data are transcribed and reviewed to determine performance characteristics and confidence levels.

The following positions in this rapidly expanding field are currently open on the R-W staff:

Senior analyst to direct mathematicians, engineers, and technical aides in missile test analysis projects and to participate in overall evaluation of missile systems performance. The test information originates from optical, radar, and telemetry instrumentation. Particular emphasis is placed upon electronic analysis of vibration data.

Engineer with wide experience in telemetry operations. The position volves planning and directing the conversion of telemetered data into forms appropriate for the analysis of weapon systems performance. Experience in the design, maintenance, and operation of telemetry data transcription and electronic vibration analysis equipment is desirable.

Engineer experienced in the utilization of missile test data transcription equipment. This position involves the planning of equipment schedules, with various research and industrial organizations, for the conversion of missile test data. A thorough knowledge of the capabilities and limitations of telemetry transcription and electronic vibration analysis equipment is desirable.

Inquiries should be addressed to: **Mr. J. H. Armitage**

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sile is the achievement of component reliability.

The approximately 300,000 separate components which go into a ballistic missile must undergo an extensive and intensive test program before a missile flight.

To illustrate the importance of the testing process in providing the exceptional reliability demanded by every part and mechanism of a ballistic missile, Dr. Ramo pointed out that each of the 300,000 components which go into an IRBM or ICBM is first tested individually. It is then fitted into a combination of 75 or 750 components.

Sapphires used for Infrared Detectors

Synthetic sapphires are playing an important role in the fast-growing field of infrared instrumentation. The unique characteristics of high-transmission properties at elevated temperatures—its strength and corrosion and abrasion resistance—make it an ideal infrared-system material.

As a heat sink, sapphire provides high electrical resistance and high thermal conductivity—both important qualities for fast, sensitive response.

As a window, sapphire is used in detector applications which require transmission of the visible spectrum with a cutoff of about 6.0 microns in the infrared band. In addition, sapphire is readily sealed to metals and ceramics, thus it can be made of any electronic assembly.

Synthetic sapphire is grown as a boule in a small oxy-hydrogen furnace in which aluminum oxide in power form is fed through the flame and the melted material collected in crystal form on a pedestal. Single crystal sapphire windows are fabricated from annealed white sapphire disk boules in diameters from one-half inch to five inches.

Sapphire components are being produced by the Linde Co. division of Union Carbide Corporation, New York, N. Y.

Cameras to Track Earth Satellites

The task of photographing a golf ball thrown from a plane at 60,000 feet is an apt description of the job assigned to the 12 satellite-tracking cameras that will be used to follow the U.S. satellite when it is launched sometime in the near future.

The three-ton, Schmidt-type wide-angle telescope cameras, designed for the Smithsonian Institution Astrophysical Observatory, will be located at 12 stations throughout the world. They are all on the orbit the satellite is expected to travel, and will be able to photograph the "moon" approximately once a week.

A master control unit containing a crystal controlled clock, a master Cathode ray tube calibrated in time increments and a direct numerical time readout unit will supply control information to the camera and its operators. Provisions have been made for slave tubes and a slave clock as may be required.

Talos Features Traffic-light System

The *Talos* surface-to-air missile features a "go, no-go" test system that tells when the weapon is ready for firing. *Talos* uses the automatic test equipment designed and built by the York, Pa. division of Bendix Aviation to determine whether all of its systems are operating properly before it is launched.

The results are recorded by lights, indicating which components have passed, or failed. A master light on the system called *Talos* Tactical Test Equipment (TATTE), will give the go-

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Guiding a missile, or speeding flight and flight environmental data back to control and tracking centers, is too much of a job for conventional communication systems. Supersonic speeds call for lightning fast data communications, coupled with the utmost reliability.

Capitalizing on the ease of converting messages into digital form, Motorola scientists and engineers have developed a number of Data Link Communications Systems suitable for piloted aircraft, as well as missiles.

NERVE CENTER FOR DATA LINK SYSTEMS



With Data Link Systems, messages that have been translated into on-off pulses can be transmitted by any of the common modulation schemes with a suitable carrier. The transmitter can be air-borne, ship-borne, or land-based. Received messages are amplified, decoded, and transformed into a form suitable for display, or stored for some future time, or used for direct control through auto pilots, for example.

One of the Data Link Systems designed at Motorola utilizes an all-transistor converter-coupler, packaged in modular form. The total system consists of eight modules, each approximately 4" x 8" x 1½". The fully transistorized circuitry is of the highly reliable diode-matrix type logical circuitry used in many digital computers. The switch type transistors employed are a product of the Motorola Semi-Conductor Division. Indicative of the stringent testing program to which the transistors are subjected is a 1000-hour life test at 85° C.

For another Data Link program, Motorola has designed a system featuring resolver-type outputs. A single time-shared servo amplifier positions anyone of the five resolvers in accordance with commands from the ground transmitter.

These two Motorola Data Link Systems aimed at solving one of the important communication problems of the missile age are examples of the complex programs conducted by Motorola for varied military needs.

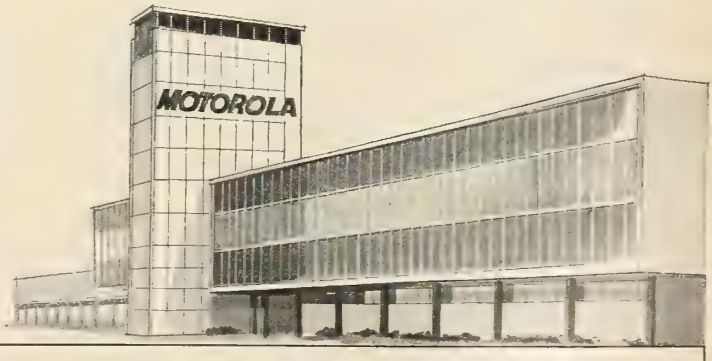
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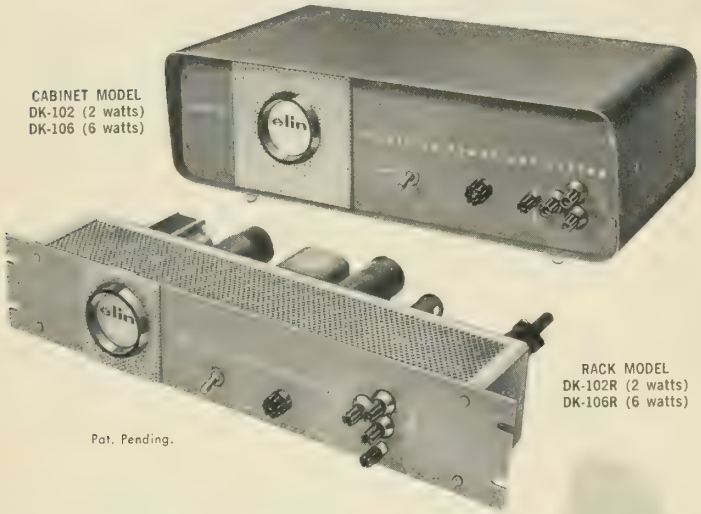


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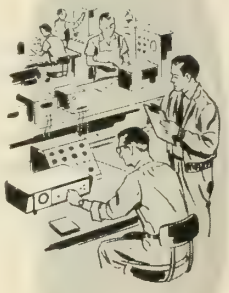


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ahead, once all components have passed inspection. This automated test equipment reduces the technical training requirements of military personnel assigned to the missile.

Talos was the first missile to employ a dual guidance system, resulting in precise accuracy at both short and long ranges. In addition, the *Talos* development program also pioneered the introduction of atomic warheads into antiaircraft missiles. *Talos* is approximately 20 feet long, and 30 inches in diameter. It weighs about 3000 pounds. The missile is accelerated to supersonic flight by a solid-fuel booster rocket about 10 feet long. The booster rocket is jettisoned when the missile reaches cruising speed.

Guidance Plant Eliminates Vibration

The world's most vibration-proof slant for the development of missile inertial guidance systems has opened in St. Petersburg, Florida. It has been so thoroughly shockproofed—through unusual scientific and construction techniques—that vibrations so small they would barely "tickle a fly's foot" can be measured inside its antiseptically clean testing laboratories.

The $4.5-million structure was erected by Minneapolis-Honeywell Regulator Co. to develop the most advanced type of inertial guidance systems yet devised for missiles and rockets. Inertial guidance is a navigational concept that permits automatic guidance—of intercontinental ballistic missiles, for example—without reference to radar, radio beam guidance, star tracking or human pilot.

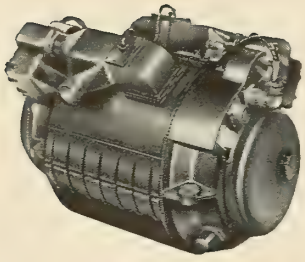
Exide Creates Missile Department

Exide Industrial Division of the Electric Storage Battery Co., Philadelphia, Pa., has created a new department to concentrate special company efforts in the rapidly growing guided missile field.

Called the missile applications department, the new unit will handle all phases of development, engineering, manufacturing and sales of missile batteries.

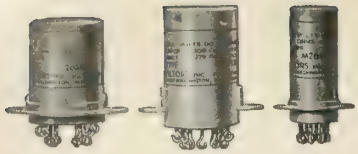
Heretofore, most of Exide's activities in the missile battery field were handled through regular departments. Effect of the reorganization is to merge all such activities into the one new department under the administrative direction of General Manager M. G. Smith.

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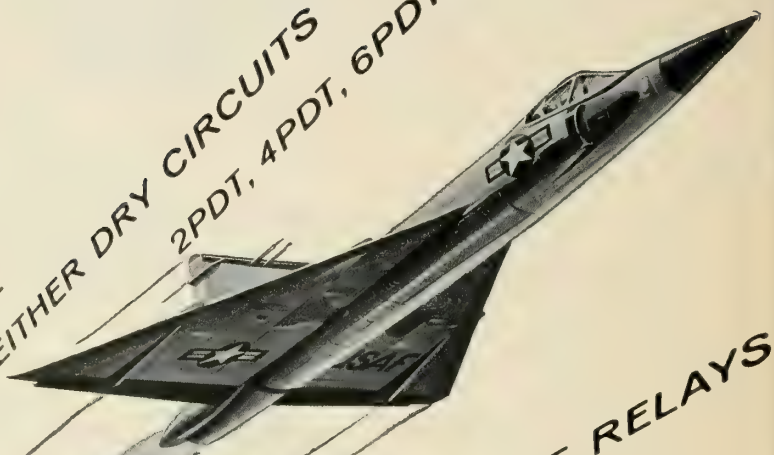


This is the brain of ISIP. Developed by Honeywell for the Navy, ISIP (Inertial System, Indicating Position) is a navigator and a primary reference for flight control systems. Using ultra-precise gyros as its basic components, ISIP needs no aid from radio, radar or human pilot. It need only be told the starting point and destination. Non-radiating and non-jammable, ISIP is another example of Honeywell's continuing contributions to the advancement of avionics.

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astrionics



by Henry P. Steier

INTEREST IN GRAVITY PHENOMENA AND THEORIES IS GROWING. At the annual Gravity Day meeting of Gravity Research Foundation, New Boston, N. H., George M. Rideout, president, reported an attendance growth from 22 in 1949 to 178 in 1957. He pointed out that discussion of these matters "had become respectable and was no longer the basis of facetious comments." Included among attendees was Igor Sikorsky of Sikorsky Aircraft Division, United Aircraft.

AN INTERESTING EXPERIMENT was described during Gravity Day by Joel E. Fisher. He rotated two 15-inch disks, separated about four inches, at 2500 rpm while 60 alnico magnets were mounted between the disks. Magnets were parallel to the shaft supporting the disks and poles were in direction of the shafts. Rotation caused a gravimeter placed two and one-half feet above the rotor to show an increased reading of five milligals (0.005 cm/sec^2) of the normal acceleration of gravity.

Explanation of the effect is difficult, says the Foundation, and cannot be attributed to eddy currents. An iron manhole cover between the rotor and gravimeter produced no change in the gravity reading. Needed condition for producing the effect was surrounding the rotor with a massive nonmagnetic material. In this case it was a pit formed by two tons of cement blocks and slate slabs. Anyone have an idea?

SECOND WORLD CONFERENCE ON GRAVITATION was held this year. According to Agnew H. Bahnson, Jr., president of the Institute of Field Physics, physicists, mathematicians and astronomers in attendance discussed the problem of the quantization of the theory of relativity. This, they decided, at present seems the best approach to an understanding of gravity.

NEAR INSTANTANEOUS ANALYSIS of chemical reactions can be made with a new time-of-flight mass spectrometer produced by the Cincinnati division of Bendix Aviation Corp. Analysis of such reactions as rocket fuel combustion, high-temperature instability of nose cones, etc., can be made in 1/10,000th second. Device uses a four-foot vacuum tube called an "ion gun." Molecules of elements under test are pulsed like radar signals from end to end of the tube, and time of flight is measured and appears as a wave pattern on a cathode ray tube. Miniature versions are expected to be used in missiles and satellites to examine composition of "space."

IMPROVEMENT IN THE RANGE OF RADAR, communications equipment and other electromagnetic devices by "three times" is said to be possible through a breakthrough in the technology of noise-free amplification. The new device which permits this long-sought goal is called a VERSITRON by Electronics Division of Advance Industries, Inc., which produced it.

AIR FORCE SAYS ADVANCES in powerplant technology and aerodynamics has completely outstripped advances in the electronics field. Col. J. S. Lambert, ARDC, told the IRE Electronic Devices meeting in Washington, D. C., that in the matter of high-temperature problems with electronics, available materials and techniques have been exhausted. He said our electronics designs are predicated upon available and understood techniques rather than limitations of materials or basic physical laws. What is needed are new materials research, new techniques and new design concepts.

ATTITUDE OF THE AF toward future high-temperature transistors is that they will not be available in the near future and electron tubes must be used. Despite good success with gallium arsenide, indium phosphate and silicon carbide materials for semiconductors, it appears ceramic-metal electron tubes will be the best high-temperature devices available for some time.

TERRIER electronic reliability

Reliability-orientation major contributor to missile electronics reliability

by **Russell R. Yost, Jr. and Fred Dreste**

Motorola, Inc.

RELIABILITY must be designed into electronic equipment; it cannot be implanted by test and inspection, though it can be maintained by them. The early dollars invested in a reliability program are most wisely spent to originate and enforce certain disciplines in design thinking.

Several years ago Motorola, Inc. contracted to re-engineer an electronic control system employed in the Navy's *Terrier* surface-to-air missile. The redesign was aimed at higher reliability and simpler producibility.

Both aims were met. During flights of design-approval models at the Naval Ordnance Test Station, China Lake, Calif., no failure has ever been attributed to the control system. Significant reductions of factory and field checkout time have been achieved. In addition, during a two-year production run only a few—and quite minor—electrical design changes have been made.

The disciplines that paid off in the *Terrier* project can be told simply. Taken singly, they seem unremarkable. Together, they are powerful and comparatively inexpensive in channeling design effort to an impressive reward. Not as much time nor money could go into these as a reliability engineer might wish. In particular, there was no ambitious program to learn precise quantitative reliability (though estimates were kept current), nor radical departures from conventional design in pursuit of reliability. Perfection in missile controls is still so far away that reliability effort is more profitable when spent in attending to the simple tasks to be described than when given over to exact measurements.

Reliability Disciplines

A reliability coordinator was appointed at project inception, reporting directly to the project leader. He was given an engineering staff whose only concern was reliability.

The coordinator made preliminary appraisals of all components in the categories from which large component totals were expected to be drawn. These categories—tubes, diodes, resistors, capacitors, transformers and several others—are the major factors in electronic equipment failures, not because the components in themselves are peculiarly weak, but because they constitute nearly all of the component equipment. It is vital, in these categories particularly, to choose the soundest components sold.

An appraisal was made based on past Motorola experience, other manufacturers' experience and an evaluation of the vendor's engineering ability, production facilities and quality control measures—and finally on the vendor's published ratings and data.

The coordinator then published a preliminary list of components recommended to designers for most applications. These components were used in breadboards (the information gained being worth the expense), as well as in engineering and development models. An entry in the list was accompanied by Motorola-assigned tolerances and deratings, related to expected environments and to wanted component reliability.

The tolerance assigned to each component was stated separately for factory and flight conditions. Moreover, each tolerance included two values, the first expressing a nonrandom shift of the mean of the distribution, and the second the random scatter effects. (In combining such tolerances, the first values are added algebraically while the second values are added in a statistical manner.)

Finally, two such tolerance pairs, one combining all positive nonrandom shifts resulting from likely simultaneous environments, and one combining all such negative shifts, were established.

Life tests were begun for all commonly applied components in the preliminary list and for certain special components foreseen as essential to the system but expected to be unreliable. Some life tests were run with components subjected only to the initially recommended loadings, and to an environment duplicating that expected as a rule in the missile for components of that category. It bears emphasis that a component environment was estimated as it would be related to the component. It was not assumed simply as the environment which, by specification, the whole missile control had to withstand.

Even when a component's environment was duplicated in tests, however, tests at normal loadings would in some components have produced too few failures to let component mean lifetimes be calculated with worthwhile accuracy. In these categories the only meaningful test possible was a "torture" comparison of similar components from various vendors. Most damaging elements of their environment—temperature extremes, vibration and shock or humidity—were exaggerated to hasten failures.

It was not generally possible from torture test data to say what a component's mean lifetime would be at normal load and in the actually expected environment. However, torture tests were considered at least to isolate for use the strongest components sold, and so to be the best use of available test time.

Component tests led to some changes in the list of recommendations and so to some discarding of stock purchased from the initial list. Made early enough, discards are a small entry in the whole price of reliability.

In addition to circulating application data to all designers, the coordina-

tor himself reviewed all component applications in developmental circuits.

Failures Analyzed

Every component failure, in either an experimental or developmental circuit, was promptly reported to the coordinator, with the circumstances and the direct evidence of failure described. Analyzing failure reports, and where possible deducing underlying failure causes, the coordinator was impelled in some cases to change component recommendations, in others to suggest alternative circuitry or, least often, to correct suspected misapplications.

The coordinator monitored (and his approval was required on) all drawings and specifications for purchased components.

Component specifications should include tests of three types: (1) initial qualification tests, which demonstrate whether or not the component design can meet requirements, (2) acceptance tests, which briefly check each received component or (by sampling) each lot of components for freedom from gross defects, and (3) quality reassurance tests, which amount to requalification tests, and aim to expose design weaknesses which have escaped the initial qualification test because samples were statistically too few, or because of slight changes in component design.

Component specifications should include all requirements imposed by the overall system requirements even when some seem farfetched at the component level or when tests to verify compliance with them seem impossible or hopelessly expensive. When a vendor objects, the requirements can be waived if they must be, but stating them at the outset firmly impresses the vendor with the designer's problems.

Much time spent communicating with the vendor by means apart from the specification can be saved by a shorter time spent in writing a more detailed specification in the beginning.

Responsibility for specifications should be vested in a specific individual or small group, rather than scattered among design engineers.

The coordinator educated the design task leaders in rules for tolerance calculations, both to furnish them with a valuable tool and to encourage reliability consciousness in design decisions. These rules are too complex to describe in detail here, but they were based on statistics and enabled the designers to calculate system flight-performance capabilities with 99.7 per cent probability as well as similar factory-performance capabilities.

The reliability of a circuit is usually the product of the individual reliabilities of all circuit components. As components are operated more conservatively, their individual reliabilities increase, but the required component total tends to grow too, increasing the number of factors in the circuit reliability product. Bearing this in mind, circuit designers sought maximum circuit-reliability compromises between the opposed objectives of conservative component operation and a low component count.

At the start of a design it is difficult to say how an electrical tolerance placed on a whole assembly should be subdivided among the constituent subassemblies, or that of a subassembly among its components, etc. A useful rule of thumb was found to be the initial assignment of one-tenth of the overall tolerance to each "piece" of a design.

Circuits were sought which did not depend on accidental characteristics of nonlinear components, or on component characteristics not controlled by the specification for the component. For example, circuits were chosen that controlled the direct current through tubes, rather than the dc voltages applied, since tube transconductance is more stable at a specific current than at a specific applied voltage.

In a few instances a circuit was adopted, seemingly the least unsatisfactory among limited alternatives, the function of which was suspected of depending to some degree on an uncontrolled component characteristic. In these circuits special effort was made to accommodate the widest possible latitude of the characteristic in question. For example, a needed system gain control was located where it automatically compensated for the lot-to-lot variations of such a parameter.

Automatic Gain Control

Circuit functions were made independent of as many electrical factors as possible. For example, a fast-acting automatic gain control (AGC) arrangement was used both for the familiar purpose of making carrier-signal rectified output nearly independent of received signal level and to abstract a low percentage amplitude modulation from the carrier signal.

Early designs provided only one AGC loop. Unfortunately, a change of received signal level, though followed by a gain change that preserved the original carrier output, altered the amplitude of the abstracted modulation voltage on which system control sensitivity depended. An improved design provided separate AGC feedback paths for carrier and modulation frequencies, rendering control sensitivity independent of received signal level.

Adjustments and trim points were kept to a minimum. These features frequently reflect avoidable design imperfections. Components generally used as trimmers incline to be mechanically weak and to suffer wide electrical value drifts with aging.

All circuits were tested individually and early in simulations of their expected operating environments. Humidity effects were especially borne in mind. Breadboarded circuits were checked for humidity tolerance by subjection to steam and by temporary connection of shunt resistances similar in value to leakage resistances foreseen in printed circuits.

Tube application information was treated seriously. Control-grid biases were kept more negative than −1 volt. Operation at very low plate currents was avoided. Heater-to-cathode resistances were assumed no higher than 0.1 megohm. Electrode dissipations were kept within normal test-condition levels rather than within maximum ratings. Tube mountings were devised that kept envelope temperatures far below those specified in vendor's test conditions. Circuit designs allowed realistically for variation of tube parameters with heater voltage variations.

No major reliance was placed on tests using limit-value tubes, since these were long-delivery items when available at all. Rather, consultations were held with tube vendor applications engineers to learn the statistical probabilities of various departures from nominal tube-characteristic values, and then theoretical calculations and simulation of tube variations were relied on to show whether circuits would function with tubes exhibiting the expected statistical variations.

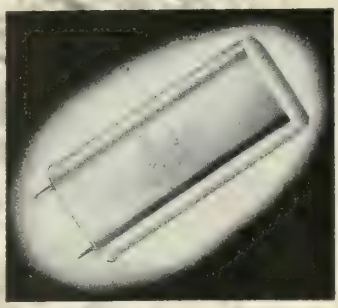
Wherever possible, circuits were operated at the highest signal levels allowed by component rating to enhance signal-to-noise ratios (noise here including dc drift, microphonics and hum, together with the commoner tube noises).

Moderate negative feedback was used often, with loop gains of 10 or 20 as a compromise between the benefits of feedback and an excessive component count.

Much attention was given to connectors and harnesses. Connectors were used that provided multiple spring-loaded current-carrying bearing points in each individual female contact. Also, connectors were chosen that included rugged shells to forestall pin and insulator damage on rough handling. Wires emerging from connectors were sealed to the shells with a rubber potting compound; flexure of cables leading to connectors was rigidly limited. All female contacts in connectors were individually checked at the vendor's factory by a pull test using a standard male pin. Wire harnesses assembled to

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connectors were tested for high-voltage breakdown and for continuity by an automatic tester.

Space restrictions prohibited the use of point-support vibration isolators, and so low "Mechanical Q's" (vibration amplification factors) were imperative in all packages. Structures were made stiff with high natural resonant frequencies, experience until then having shown that this was the most practical way to realize low Q's. It should be said that more recent techniques incline rather toward the use of "lump" structures with layers of dissipative materials sandwiched into the structures to absorb vibratory energy.

The system's packages were to be mounted on a T-beam in the missile. An early mockup of this beam, loaded with dummy packages, disclosed a fundamental beam resonance at about 120 cps. Package internal resonances accordingly were kept well above 200 cps to avoid any risk that they might coincide with the beam resonance.

Much thought was given to heat flow. The primary problem was cooling during test, where the outside skin of the missile control served as the heat sink. The high temperature reached by the skin during flight was not of concern because the flight duration was small compared to the thermal time constant of the control.

Because of mechanical design requirements, metal heat-conducting paths to the outside skin were not possible. Instead, heat was transferred metallically from hot components (such as tube envelopes) to larger surfaces such as chassis or tube blocks, and normal air convection was then relied on to transfer heat from these "couplers" to the outside skin.

An early model of the control system that accurately represented the final model in heat transfer characteristics (but which included only preliminary circuitry) was built in order to evaluate the design. Thermocouples were embedded in first-sample potted assemblies ordered from vendors for use in this model. Tests showed that during the specified test cycle, the maximum temperature rise above outside ambient was only 45°C; many areas exhibited only a 35° rise.

Work to gain immunity to high humidity centered chiefly on improvements to printed circuit boards. Numbers of board materials and coatings were investigated, and conductor spacing was standardized at .062 inch. Even after an optimum selection of materials, however, electrical designers were obliged to observe certain restrictions rarely met in other wiring. Among others, circuit impedances exceeding 0.5 megohm required special

approval; guard circuits were required in many instances.

Establishment of a design does not end the reliability tasks. As engineering models are built, all designers responsible must perform or witness the evaluation tests, particularly environmental tests, analyze failures and make design corrections. Complete reporting and exhaustive analysis of all failures is the duty of the designers. The insight gained must "feed back" and culminate in design refinements for as long as the schedule permits.

Certain factory tolerances on parameters of subassemblies, assemblies or whole systems, are not predictable from component tolerances in any simple way. They must be assigned after direct measurements of the parameters of a number of subassemblies, etc., normally in late-engineering model systems when these and production models are expected to be nearly identical. (The route from measurements to tolerances is not recited here.) These assignments are of interest both to the reliability coordinator and to the quality control department.

Quality control must be arrived at or be furnished with tolerances early in a first production run in order to monitor manufacturing processes. The reliability coordinator and all designers of a system are concerned because the agreement of tolerances finally set is some measure of the perfection of a design. This process, in the case at hand, was notably successful. Of the hundreds of such tolerances most were set on the basis of 15 design-approval models, and less than 2 per cent were changed during the following pilot and production runs.

Sufficient Data

Sufficient data to establish the exact flight reliability of a missile control is not readily available and does not yet exist for the *Terrier* control. (However, as mentioned earlier, no reliability failures have been noted in design-approval flight tests.)

The emphasis placed on reliability at every phase of the re-engineering of the *Terrier* guidance control system has resulted in a marked improvement of system producibility and tactical effectiveness. The engineers "lived" reliability on this project, acknowledging its importance in the selection and application of components, in the choice of circuit designs, in the mechanical design approach and in the production support effort. The techniques were simple but required constant emphasis. The application of statistics to electronic design was new to most of the engineers when they started but became second nature before they were through.★

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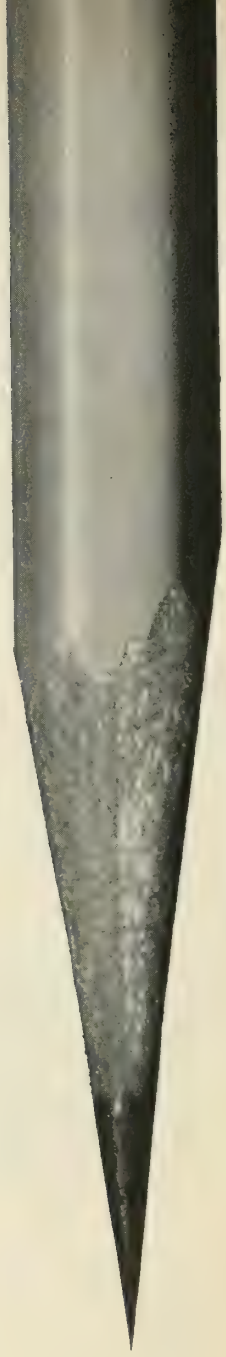
Incremental shaft rotation: 2 degrees.

This is one of the many applications for the Stepper Motor — a device for translating electrical pulses into accurate, bi-directional, incremental shaft displacements.

The Synchro Positioner uses two Stepping Motors, an Autosyn differential, and a built-in pulse generator. One motor positions the Autosyn Shaft in coarse increments in either direction, while the other motor, using a different gear ratio, positions the same shaft in vernier increments in either direction. As the reset command signal is of steady-state type, the built-in pulse generator permits use of the driving motors for the reset function.

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training potentialities of synthetic missiles

Missile management is recognizing the need for training priority and budgetary support

by J. Gordon Vaeth and
Lt. Cmdr. John Huson, USNR
U.S. Naval Training Device Center

MISSILEMEN in both government and industry increasingly are recognizing the importance of training to the effectiveness of weapons now in development or production.

Regardless of the development and refinement which go into it, a missile is still at the mercy of the men who handle, assemble, checkout, "troubleshoot," fuel, fire and, perhaps, control it. As such, its reliability and performance are subject to human failings and errors.

And whereas ordnance personnel mistakes with weapons of pre-atomic days might have been destructive and tragic, when made with nuclear arms they can be globally catastrophic.

A new concept in missile engineering—a concept intended to reduce or eliminate training degradation of costly and short-supply missiles—has recently been advanced by training specialists of the U.S. Naval Training Device Center, Port Washington, N. Y. It emphasizes maximum and, if possible, total use of synthetic equipment.

Industry is beginning to see training as a critical, yet often overlooked, factor which is essential if a stockpiled missile is to become a live and effective weapon of defense or offense. Missile management is aware that training requirements must form an integral part of any weapon system, if that system is to be complete or effective; long-range planners are giving training considerations priority attention and budgetary support as never before.

Yet even when training problems are correctly anticipated, the solutions are usually stereotyped. The usual procedure is to establish a service school for instruction on the weapons and to divert a number of operational missiles from the production line to be used for this purpose.

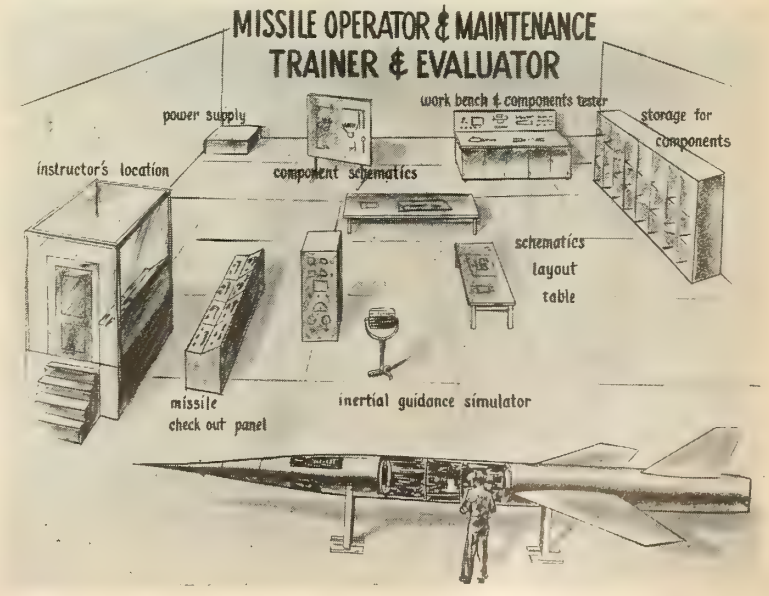
Operational missiles, however, are not designed, engineered or intended to undergo continual classroom disassembly and reassembly by inexperienced trainees. As a result components soon wear out. The missile is rapidly degraded until finally it has to be scrapped or completely overhauled at a cost approximating the price tag of a new missile itself.

Experience has shown that complex operational missiles are good for about three months of classroom usage; then they must be replaced. Experience has also proven that long before the missile reaches the "replace" stage, it is heavily subject to "down time" which can seriously disrupt orderly scheduling of classes and efficient instruction.

Formal school training with operational missiles suffers from still another disadvantage. Using production-line hardware, it is difficult for instructors to illustrate any variety of controlled malfunctions. Since the best way to evaluate a missileman's competence is to give him a number of different type troubles and check his ability to detect, isolate and remedy them, this means that technical training on operational equipment is, without considerable modification of that equipment, only partly adequate at best.

The concept evolved by the Office of Naval Research's NAVTRADEVCEN seeks to overcome these difficulties. It proposes to do so by substituting synthetic equipment for operational gear wherever possible.

Cornerstone of this new concept is a full-size dummy missile. Every component of the operational bird vis-





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ible or accessible to maintenance men or to firing crew members is reproduced to exact size and appearance. Access hatches and check points are realistically duplicated. The dummy is a detailed "live" mockup.

Systems and components which launching, operator or maintenance personnel have to check, adjust, repair or replace on the actual missile, are synthetically activated by simulation techniques. The black boxes are all there, their inputs and outputs reading the same on the missile test equipment as if they were operating in the genuine weapon itself. Yet the boxes are dummies, activated to give correct responses by straight electrical, rather than electronic, simulation means.

The dummy, with its synthetically "live" components, is connected to the appropriate missile checkout or fire-control panels. These, too, are synthetic and duplicates of the actual panels in every external or visible detail. They provide the correct light and meter indications as dictated by the "condition" of the dummy missile. This "condition" is controlled by an instructor who can introduce from his console a variety and number of typical malfunctions. He must determine how quickly and accurately the trainees can spot and repair the troubles. If component replacement is required the dummy offers the same difficulty of access as does the real missile. The time it takes for the malfunction to be remedied and the actions taken by the trainees are automatically recorded for post-exercise critiques.

The national economy cannot long endure the wholesale degrading, wearing out and expending of costly, complex missiles for strictly routine training purposes. Less costly ways must be found, although it is recognized that a certain number of proficiency or "confidence" firings will always be required.

New simulation techniques and synthetic equipment can provide these ways. Missile fire-control radars can be activated and moving targets synthetically generated on their scopes. And by using the latest in the simulation engineer's bag of tricks, the missile itself can now be synthesized—for formal technical training, for the exercising of firing crews, and for evaluating the readiness and ability of Army, Navy, Marine Corps, and Air Force units to checkout, troubleshoot, and launch the missiles which industry is placing at their disposal.★

(Opinions and assertions are those of the authors and are not to be construed as official or as reflecting the views of the Navy Department or the naval establishment at large.)

space communications tested with X-17

By Henry P. Steier

COMMUNICATIONS between space ships or missiles and earth probably will not pose too much difficulty once they are free of the earth's atmosphere. It is in the region between sea level and a few hundred miles altitude, which contains gases, that radio transmission difficulties occur.

These transmission problems are associated with aerodynamic heating. The shock wave that exists around the nose cone of a hypersonic missile causes intense heating of the air round it.

Between the shock wave and the missile surface is a shock layer in which "aeromolecular" effects occur. These are induced by the high temperature. Among these effects is production of free electrons. This causes communication interference.

Very little has been revealed about findings thus far collected on radio transmissions from hypersonic missile tests. Probably some of the most significant information about the problem has been collected by Lockheed Aircraft Corp.'s Missile Systems Division.

About a dozen flights were made by Lockheed's X-17 re-entry test vehicle. Much information about what happens to radio signals in flights from sea level to about 100 miles altitude is believed to have been collected.

The radio information was, of course, relative to re-entry phenomena in connection with nose-cone research. However, some of the vehicles were fired specifically to develop telemetry systems suitable for the X-17 flight environment.

Tight Military Security

Some time ago, Lockheed engineer N. Turveen admitted (m/r, April 1957) his company had experienced "a peculiar phenomena observed in the variation of radio frequency field strength under X-17 flight conditions."

Beyond that, he said, military security was tight-lipped on exactly what happened. However, the company is continuing its studies in this problem area, as evidenced by recent announcement of a Lockheed Space Communications Laboratory.

The new facilitiy located at Sunnyvale, Calif., is a three-story, 10,000-sq.-ft. building in which space conditions as they exist hundreds of miles above the earth can be re-created.

According to the company, antenna design and installation for the Navy's *Polaris* ballistic missile are among the projects being studied in the new laboratory.

In a recent report on missile aerophysics phenomena of electronic import, Lockheed engineer Daniel Bershader discussed some of the features of environment surrounding missile-type vehicles in hypersonic flight.

On a theoretical basis, Bershader said, effect of ionization of the compressed and sheared air of a boundary layer around a vehicle on transmission of microwaves can only be calculated approximately.

The boundary layer is an area around a missile which exhibits a velocity profile of air extending from zero to near-free-stream value of air around a vehicle. Air is brought to rest by impact with a nose cone. The kinetic energy is transferred to thermal energy.

At Mach 22, at 150,000 feet altitude, the temperature created would be 13,000°F. From the highest boundary-layer temperature point on the nose cone to points along the afterbody of a missile, the temperature profile changes.

At about 2,200°F, which corresponds to a stagnation, (or zero air molecule velocity condition) for Mach 6, energy balances in gases composing air come into play. Near Mach 10 oxygen disassociates. Chemical reactions occur. Nitric oxide is among the formations produced.

Disassociation of nitrogen starts at about 10,000°F, corresponding to a stagnation temperature for Mach 17, and at this point ionization becomes significant.

Heat and Light Produced

At the higher Mach numbers much of the energy released goes into atomic-molecular processes. These are dynamic and accompanied by recombination and de-excitation phenomena. Heat and light are produced. This occurs at certain rates depending upon



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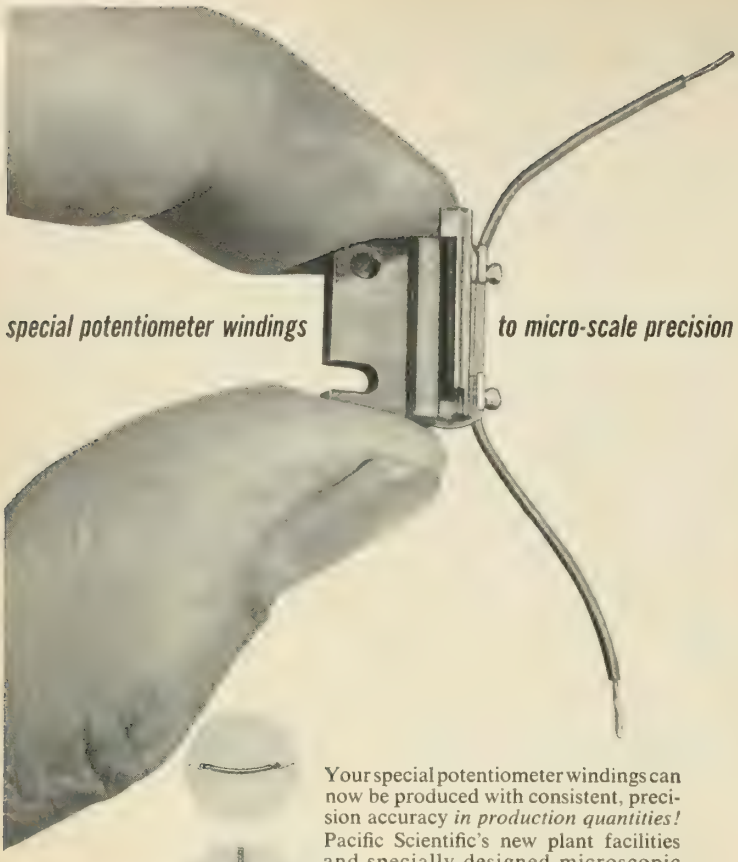
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boundary-layer temperature profiles. The reactions, however, require time, since there is a mean-free-time between particle collisions in a gas.

Meanwhile, the surface layer of a hypersonic vehicle is inhabited by free charges of ions and electrons. It is these, Bershader said, that one would expect to effect the radiation pattern of a transmitting antenna on a vehicle body. Also, the impedance match between antenna and atmosphere would be affected by the local environment.

In considering theoretical solutions to this problem, the parameters would be electron concentration distribution, which controls the attenuating path length; frequency of transmitter, reflection and refraction, and electron collision frequency.

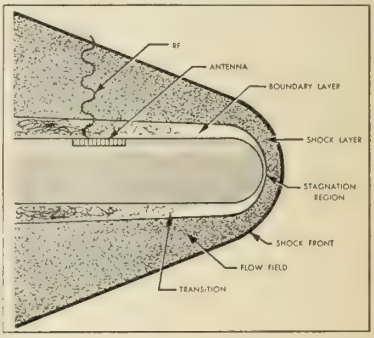


Diagram showing complex environment around a blunt-nosed vehicle at hypersonic speed. Transmission of RF energy through boundary-layer region of atomic-molecular process activity poses frequency dependent problems.

The relationship between transmission frequency and the effect depends upon the "plasma" frequency, which in turn is a functon of electronic charge and mass.

Although the determination of attenuation factor can be approached mathematically, much more information is needed on what goes on in a hypersonic vehicle's surface layer. It is known that at velocities of about 20,000 ft./sec., ionization of sheared and compressed air of the boundary layer yields a conductivity equivalent to that of fused sodium chloride, Bershader said.

The loss of radio energy in db per inch is directly proportional to a complex propagation constant for wave passage through the ionized medium.

To minimize the attenuation, it was noted, it is necessary to make the transmitting frequency "appreciably larger than the characteristic plasma frequency of the boundary layer."

Recently it has been reported that attempts are being made to use ionization trails from aircraft and missiles as low-frequency antennas. In this case high electrical conductivity of the ionized paths is used for coupling. ★

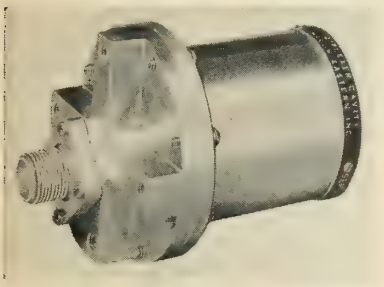
Circle No. 70 on Subscriber Service Card.

NEW MISSILE PRODUCTS

TELEMETERING DIPLEXER

Hycon Eastern, Inc. has introduced a high-power telemetering diplexer, type 1231. The instrument feeds signals from 2- to 100-watt transmitters into a single antenna system and is designed to satisfy military requirements for use in test missiles and telemetering.

Environmental specifications are: shock to 100 g, vibration to 200 g at 2000 cycles, temperature —70°F to 350°F. Units made of Invar may be provided at



extra cost for use up to 500°F.

Other specifications include frequency range: fixed-tuned between 215 to 250 mc/s; isolation: 28 db with 10-mc separation, 25 db with 6-mc separation; attenuation: less than 0.3 db; power-handling capacity: rated at 100 watts cw, size: each cavity approximately 3"x4"; weight of total system: 3.7 lbs, pressurization: diplexer cavities are filled with dry air and permanently sealed.

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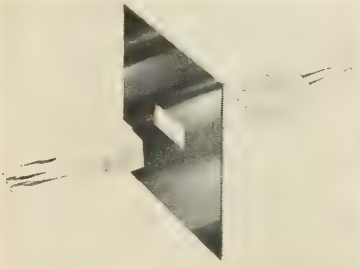
EPOXY COMPOUND

An epoxy compound has been developed by Minneapolis-Honeywell for potting transformers. The compound featuring a patented hardener, is a low-coefficient-of-expansion material exhibiting unusually high electrical resistance at temperatures up to 350°F.

Circle No. 216 on Subscriber Service Card.

MULTIPLE CONNECTOR

Amp, Inc. is producing a new type of self-anchoring through-panel multiple connector that eliminates the necessity for supplementary mounting devices. The product is polarized to eliminate circuit error, and the contacts with the mount-



able and disconnect units are identical, self-cleaning, and recessed for safety. The connector may be used for free-hanging, multiple connecting of circuits, as well as for through-panel mounting.

Circle No. 203 on Subscriber Service Card.

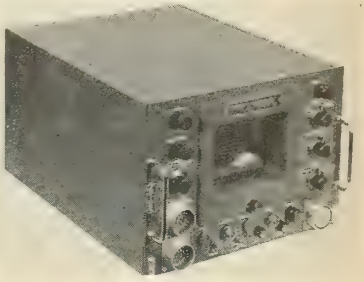
SOLID STATE BATTERY

The Patterson, Moos Division of Universal Winding Co. has developed a miniature, high voltage, solid-state battery that is capable of delivering high current drains for long periods of time.

Called the "Dynox 95," the first model of the new battery is 1¼" long, ⅜" in diameter, and has a potential of 95 volts in 0.14 cubic inch. It can supply a steady current of $1x10^{-9}$ amperes for 176,000 hours at 70°F with only a 10% voltage drop, or a flash current of 20 microamperes. It can be stored for 20 years without losing its power. Other characteristics include resistance to extreme shock or vibration, performance at extreme temperature ranges, including the ability to operate after temperature cycling between —100 and 170°F.

Circle No. 211 on Subscriber Service Card.

MONITORSCOPE



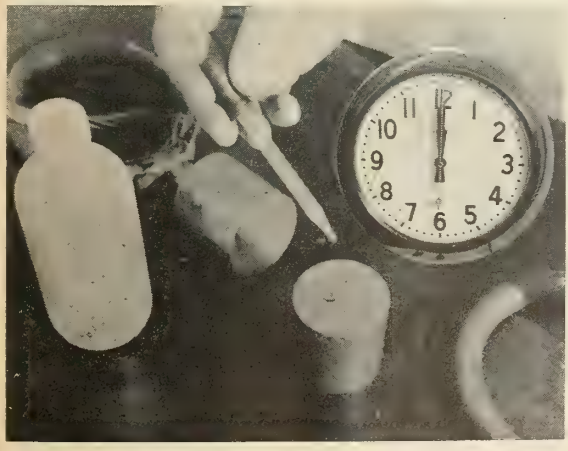
Applied Science Corporation of Princeton has developed an electronic tool enabling engineers to test 86 test point variables at a glance. The instrument may be used for flight instrumentation, production-line testing and for monitoring. Test data can be observed as a varying line display on an oscilloscope screen, while individual data samples are presented in bar-graph form. The device is available for field or laboratory use.

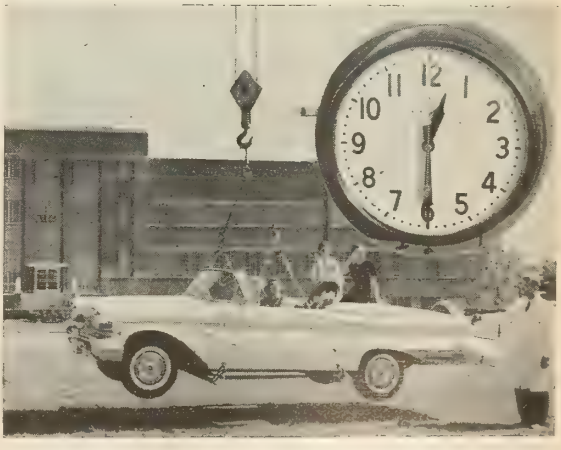
Circle No. 200 on Subscriber Service Card.

PORTABLE POTENTIOMETER

A new type portable potentiometer featuring interchangeable scales, and automatic compensation has been introduced by Technique Associates, Inc.

ADHESIVE LIFTS 5000 POUNDS AFTER 30-MINUTE SET





Eastman Chemical Products, Inc. has developed a new adhesive with rapid-set characteristics and capable of bonding a wide range of materials. Designated Eastman 910, the new material is shown supporting over 5000 lbs. after one drop of it was placed between two pieces of steel rod 30 minutes previously. The adhesive requires no heat, pressure, evaporation of solvent, or long curing time. It bonds wood, metals, glass, ceramics, rubber, plastics, porcelain and other materials. Eastman 910 has proven valuable in joining small intricate assemblies and is in limited production at the company's laboratory.

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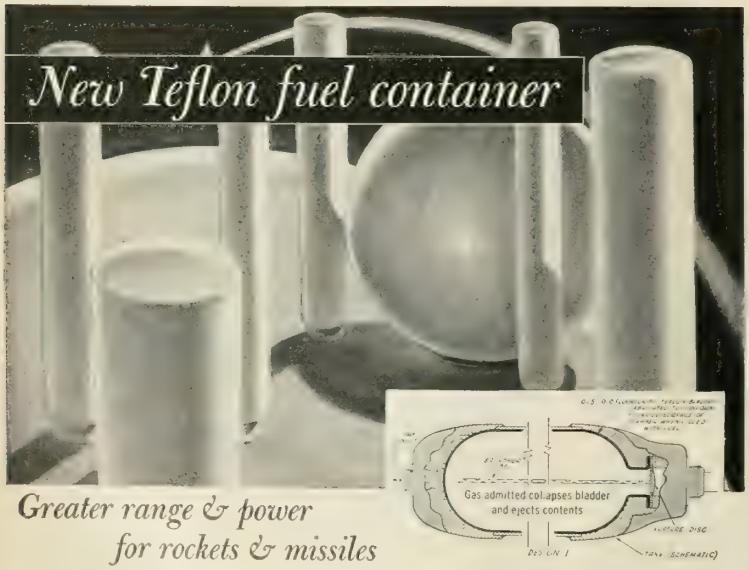
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Manufacturers are invited to submit requirements for quotations

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Interchangeable scales permit measurements of a wider range of temperatures and voltages.

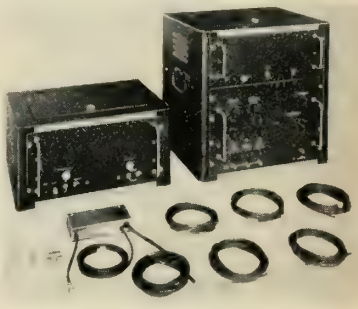
Known as the Thermotest-I, the instrument is an all-purpose testing device for making highly accurate temperature measurements from −200°F up to 600°F. Ordinary thermocouples are used. The instrument will also measure voltages from zero up to 21 millivolts. Scales which are calibrated in degrees centrigrade are also available.

Circle No. 208 on Subscriber Service Card.

RADAR INTERFERENCE BLANKER

A radar interference blanker, Model RB-128, which eliminates "main bang" interference in a group of normal and MTI radar sets, or reduces it to a negligible value, has been developed by Empire Devices Products Corp.

In operation, the interfering signal is bracketed with a negative blanking gate to eliminate it from the protected radar's display. Since the PRR of the protected radar and that of the interfering radar are usually not synchronized, any loss



of displayed information is unimportant.

The RB-128 blanker system is self-contained; no additional transmitters, receivers, telephone lines or coaxial cables are required, irrespective of the number of interfering radars. Distance from the offended radar is not a factor, so interference from shipboard or airborne radars is also eliminated.

The blanker may be added to existing radar installations without appreciable modification of operating equipment. The use of instantaneous automatic gain control circuits and very low time constants in grid circuits reduces the guard-band receiver's susceptibility to jamming well below that of the radar being protected.

Circle No. 215 on Subscriber Service Card.

HELIUM DEWAR

Information is now available on design of Hofman Laboratory's new solenoid dewar flask for the study of the effects of magnetic fields on various properties of solids at liquid helium temperatures in the laboratory.

Circle No. 217 on Subscriber Service Card.

ACTUATOR MOTOR

Viking Tool and Machine Corp. has developed an actuator motor featuring high starting-torque that is suited for remote control switching, homing devices, valve operation and other applications. It operates at temperatures up to 500°F at 60 cycles ac, or 400 cycles ac as well as pulsating dc.

The motor is basically a compact, lightweight ac rotary solenoid with a vibrating rate of 120 cycles/second when

operated on 60 cycle ac. This rapid vibratory motion is translated into rotary stepping motion through a fast-acting one-way clutch.

The company says the device features higher torque for its size and input power than normal solenoids since it is always vibrating within the most efficient portion of a solenoid's stroke and does not have a relatively low torque initial pull-in. The device operates at moderate speed and at either 60 cylces or 400 cycles will operate at free speeds of less than 300 rpm.

Circle No. 209 on Subscriber Service Card.

CRYOGENIC PUMP

Sundstrand-Denver has developed a compact, lightweight, piston-type pump suitable for pumping liquefied gases such as nitrogen and oxygen. The pump has the capability of pumping liquid nitrogen at pressures of over 3000 psi at speeds of over 3500 rpm. Sustained operating periods of over one hour have been obtained repeatedly without any form of lubrication. The performance data for the pump are: capacity @3500 rpm, 1.75 gpm; horsepower @3500 rpm, 3.8 hp; weight 2.5 lbs.

The pump has nine axial pistons and is of the fixed displacement type. Metal parts have been selected to be compatible with liquid nitrogen. Minor material changes can be incorporated to permit satisfactory operation using liquid oxygen. Since this pump is a modification of a standard Sundstrand hydraulic motor, larger capacity pumps can be provided with relatively little development.

Circle No. 210 on Subscriber Service Card.

IGNITOR DEVICE

Electronic Specialty Co. has introduced a new product to check the ignition and squib circuits in guided missiles and rockets. Designed to be more effective than previous methods of testing these circuits, the device takes the current for the normal time and then breaks the circuit just as an ignitor or squib would. The unit can be used for thousands of test firings.

An additional feature is the indicator arrangement. A small translucent button pops out to show that the firing circuit has operated. A mechanical reset makes the device ready for the next test immediately after firing with no part replacement. The device is available in a variety of maximum current ratings and operating time characteristics. Because of the nature of simulation and test devices, the units are produced to customer requirements.

Circle No. 204 on Subscriber Service Card.

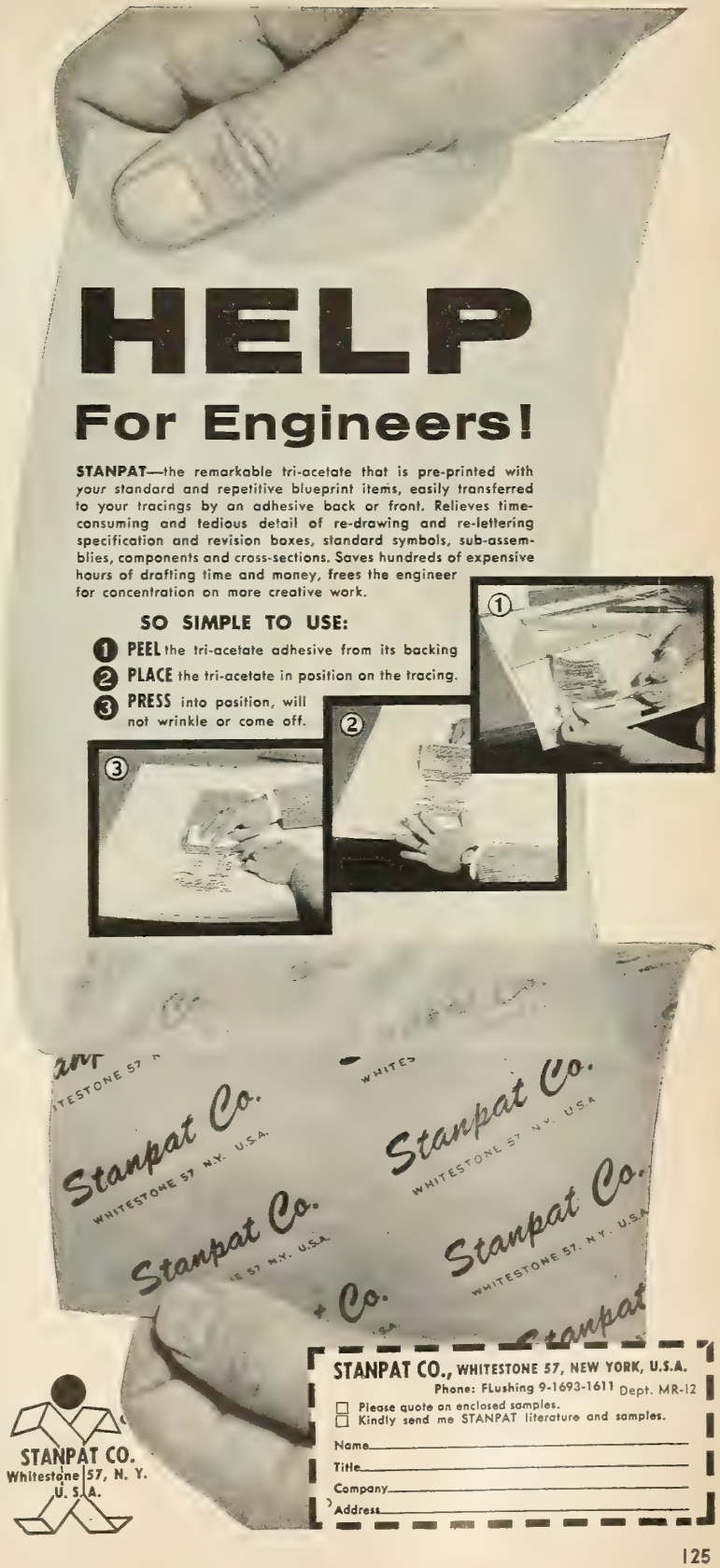
PITCH-YAW INDICATOR

Edcliff Instruments now has its Pitch-Yaw Indicator in full production. The free-swiveling aerodynamic head provides potentiometer output linear with angles of pitch and yaw.

High-temperature components used throughout the instrument permit operation at high Mach numbers. The Model 4-1 is available in ranges up to 27½°, with an indicating accuracy of 0.1°. Overall length is 4".

Metering is provided by two precision wire-wound potentiometers with single-wire function taps. Static or total head probes are available, either singly or combined.

Circle No. 205 on Subscriber Service Card.



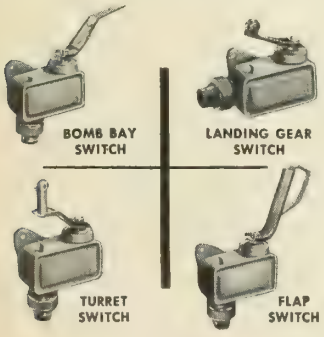
new ELECTRO SNAP ROCKET SAFETY SWITCH



Sketch shows typical switch and rocket tube application. Rocket switch controls various indicator, sequence and other electrical circuits. Several models now in production. Send us your design requirements.

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Missile Business

by Seabrook Hull



NOTHING COHERENT will be done about the U.S. missile program before the start of the new year. Between January 1 and February 1, 1958, these things will happen: Congress will return; the President's Budget and State of the Union Messages will be presented to Congress; tax payments January first will begin to swell the Treasury's cash balance. Until all of these things are done, little is possible in the way of reorganization of the U.S. missile program.

One exception, of course, is that Congress can and will start its investigations earlier. Lyndon Johnson's Senate Preparedness Subcommittee held five days of hearings starting November 25. Witnesses from both inside and outside the Government were heard. Johnson wants to have a report ready for Congress when it reconvenes.

UNSPECIFIC THOUGH THEY WERE, the President's security and science talks do give a pretty clear indication of Administration thinking in some of the more costly defense areas. For example: No plans to kill off Strategic Air Command any time soon; means more planes will be bought; SAC bases further dispersed. Also, SAGE is relatively worthless (some experts say completely worthless) for in-time interception of large ballistic missiles; means more and better early warning gear. Anti-missile missile: Both Army and Air Force projects will be pushed. The President, in talking about future missile spending, pointed out that we are now spending "more than $1 billion" on missile research and testing. Production, deployment and installation of the birds, particularly the big ones, will really run costs up. For example, ICBMs will certainly be deployed underground; IRBMs, probably. These installations will require extensive facilities.

PAYMENTS HAVE BEEN LIMITED to 80 per cent on cost-reimbursement contracts, according to an order of Defense Secretary McElroy. The other 20 per cent contractors will be expected to put up out of their own working capital or borrowed funds. Cost of using their own money for working capital will be taken into account in costing the contracts. Meanwhile, the Air Force (but not Army and Navy—yet) will attempt to rewrite some $250 million in cost-reimbursement contracts now outstanding. They will be made to conform to the 80 per cent provision.

This device will limit cash outlays now, and thus help the budget. But the Government must pay sometime; means things will be tougher at the end of the contract when final settlements are made.

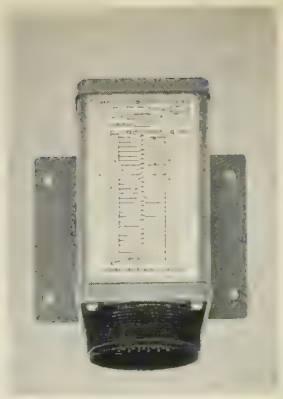
BASIC RESEARCH WILL GET ANOTHER BOOST IN FUNDS. This is being ordered by Defense Secretary McElroy in another move reversing the trend begun by his predecessor, Mr. Wilson. Not only are more funds being voted, but an effort will be made to institute management practices to encourage a greater amount of basic research.

DON'T BELIEVE ADMINISTRATION ASSURANCES that no substantial increase in missile spending will be necessary. It's virtually certain that the President will ask to have the statutory debt ceiling raised. It's also virtually certain that before the current fiscal year is out the Pentagon's missile and space-flight program will be overplanned rather than underestimated. The administration cannot risk another setback such as that incurred with the *Sputniki*. And some of these programs will be greatly accelerated in order to quickly achieve a major space flight "first" ahead of Russia.

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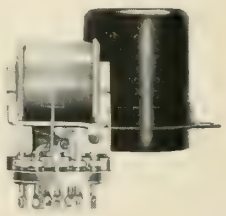
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people

John R. McAllister has been promoted to manager of purchasing for Philco Corp.'s government and industrial division. He previously was assistant manager at the division.

Five appointments have been made at Thiokol Chemical Corp.'s Utah division. **John Higginson** has been named general manager. Other management appointments include **V. H. B. Wilhite,** technical director; **Anthony T. Guzzo,** head, manufacturing department; **William D. Kelley,** head, quality control department; and **J. E. Dieter,** head, administrative department.

Dudley B. Hartung has been named applications engineer by Sanders Associates, Inc. for its line of electrohydraulic servo valves and servo systems.

Ben L. Ettelson has been appointed turbo division project manager for American Machine & Foundry Co.'s participation in the *Atlas* ICBM program.

Lt. Col. George R. Steinkamp has been named head of the Department of Space Medicine at the Air Force School of Aviation Medicine. He succeeds **Dr. Hubertus Strughold,** who has been appointed advisor for research to the commandant of the school.

Frederick N. Mayer has been appointed manager of contract sales and **John P. Thompson** as manager of product sales for the electronics division of F. C. Huyck & Sons. Other appointments by the company include **Leonard Rose,** head of airborne instrumentation section; **Sidney Herman,** head of semiconductor products section; and **Arthur Schlang,** head of simulator systems section.

Robert A. Jewett has been appointed product sales manager of chemicals, phosphors and semiconductors for the chemical and metallurgical division of Sylvania Electric Products Inc.

James E. Shondel has been named government sales manager for International Research and Development Corp. He formerly served in Air Force procurement.

Paul J. Case has been appointed controller at Stavid Engineering, Inc. He previously was manager of the accounting division.

George P. Brandt has been appointed production manager of the new Callery Chemical Co. plant at Lawrence, Kan.

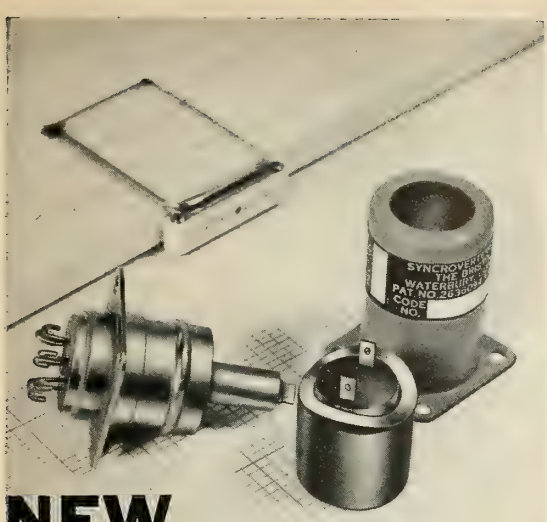
Herbert R. Keith has been named director of marketing services for International Business Machines Corp.

Donald M. Miller has been elected executive vice president of Airborne Instruments Laboratory. He had been vice president in charge of the engineering and production division of the company.

Col. Benjamin G. Holzman has been appointed director of research at the Air Research and Development Command, and will have staff supervision of the research effort at all the ARDC centers including the Office of Scientific Research.

Lloyd E. Stires, formerly a project planning group supervisor for the California division, has been named manager of the project planning department for the Van Nuys branch of the Missile Systems division of Lockheed Aircraft Corp. Another appointment at the Van Nuys branch is that of **Orbrey O. Burns** as acting manager of master scheduling. He succeeds **E. R. Proctor,** who has been transferred to the San Francisco Bay area where he is assigned to the office of **Wilbur D. Snow,** director of the product planning department.

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NEW LOW-NOISE CHOPPER

Bristol's Syncroverter† chopper is now available in a low-noise, external-coil model for critical dry circuit applications.

This new external-coil chopper virtually eliminates capacitive coupling between signal-circuit contacts and driving coil leads. Peak-to-peak noise levels are usually *less than 100 microvolts* across a 1 megohm impedance (rms noise, in the order of 10 microvolts).

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Driving Frequency Range:	0—1800 cps
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***Coil Current:**	70 milliamperes
Coil Resistance:	52 ohms
***Phase Lag:**	60° ± 10°
***Dissymmetry:**	15° max.
***Switching Time:**	15° ± 5°
Temperature Ranges:	—55°C to 100°C or —65°C to 125°C
Operating Position:	Any
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Engineers and scientists are invited to address inquiries to: Research and Development Staff, Sunnyvale 7, California.

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Bomarc Switches to Solid Rocket Booster

An advanced model of the *Bomarc* surface-to-air missile will employ a solid-propellant rocket booster (m/r Sept., p. 164). Present IM-99, recently ordered into production, is boosted to altitude and ramjet-engine velocity by an Aerojet liquid-propellant engine.

The switch to the solid-propellent system will improve logistics and provide a possible increase in range, altitude and velocity. The liquid system now used forms the major portions of the missile's weight and volume. It cannot be cropped after burnout, a feature which undoubtedly imposes performance limitations that would not be present with a droppable solid-propellant booster system.

Northrop Missileers Report for AF Duty

Twelve missile specialists from Northrop Aircraft's customer field service section have reported for duty with 6555th Guided Missile Squadron at Patrick AFB to assist in training of the Strategic Air Command for *Snark* SM-62A operations.

The proficiency training team, whose members have undergone a rigorous training program over the past months, is headed by Jim McFarlane. McFarlane formerly was an engineering assistant on *Snark* guidance tests and later worked as guidance test engineer during launching tests at Cape Canaveral.

Additional Helium Production Requested

The Interior Department feels that increased missile needs warrant the construction of an additional helium-producing plant. The plant, costing $14 million, would increase output by about 240-million cubic feet.

The government now has four plants producing about 365 million cubic feet annually. Present missile systems use an extensive volume of the gas for propellant pressurizing systems.

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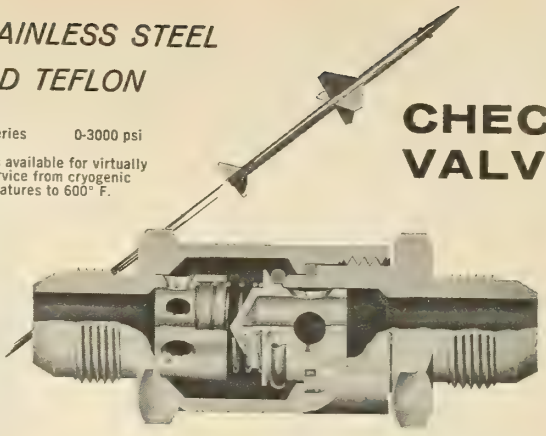
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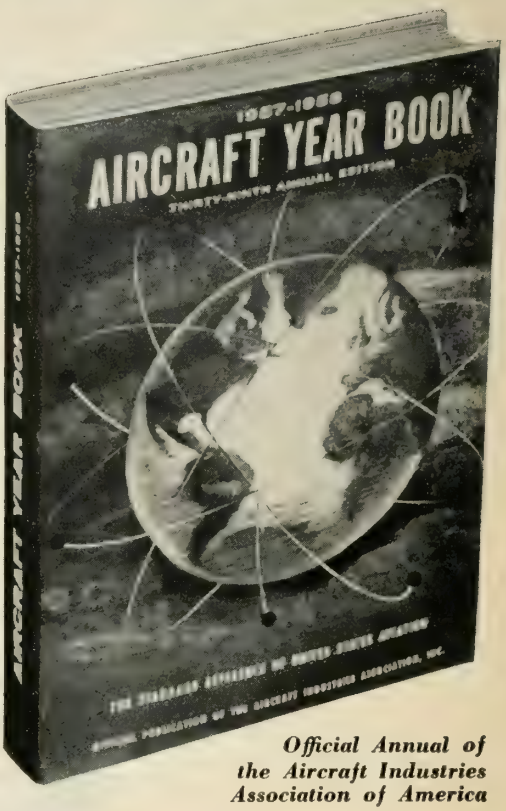
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Curtiss-Wright Expands Missile Effort

Curtiss-Wright Corp.'s latest acquisition in the missile field is the H. A. Wagner Co. of 14707 Keswick St., Van Nuys, Calif. It will operate the company as a wholly-owned subsidiary of its Aerophysics Development Corp. Latter is located at Santa Barbara, Calif.

FMC Corp. Develops *Hawk* Loader Vehicle

The completion of design and development of a new lightweight, self-propelled track vehicle for the *Hawk* loader, the first mobile missile handling unit of its kind, is the latest achievement of the ordnance division of Food Machinery and Chemical Corp.

The track vehicle was built for Northrop Aircraft, Inc., by FMC as part of the U.S. Army's *Hawk* surface-to-air missile system. FMC produced the track vehicle under contract to Northrop.

Aerophysics Awarded *Dart* Missile Contract

An additional contract, totaling $826,963, has been received by Aerophysics Development, Santa Barbara, Calif., for continued development of the *Dart* antitank missile.

Operational status of the *Dart* has not been officially announced. Development is by Aerophysics with production by Utica-Bend Corp. (subsidiary of Studebaker-Packard).

Marquardt Test Facility Under Way

Marquardt's Ogden, Utah, facilities, which started delivering production ramjet engines for the *Bomarc* missile over two months ago (m/r Sept. '57, p. 168), has broken ground at the site of its ramjet-engine test facility. The test facility will operate in conjunction with the production plant.

Marquardt now holds a total contract award of $30 million for its Ogden plant.

Mack Trucks, Inc. Forms Electronics Division

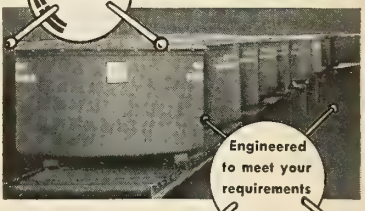
The electronic research and manufacturing facilities of Mack Trucks, Inc., are being formed into a single division. Called the Mack electronics division, it will permit greater coordination of effort in the rocket, missile and aircraft fields.

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- *concept*
- *systems analysis*
- *development & testing*
- *prototype*
- *production engineering*

Ordnance research and engineering is complemented by the production facilities of the Aircraft Division of Rheem Manufacturing. Numerous ordnance products and systems are currently in production.



The Rheem developed Super Nike warhead system being tested on rocket sled built by Rheem.

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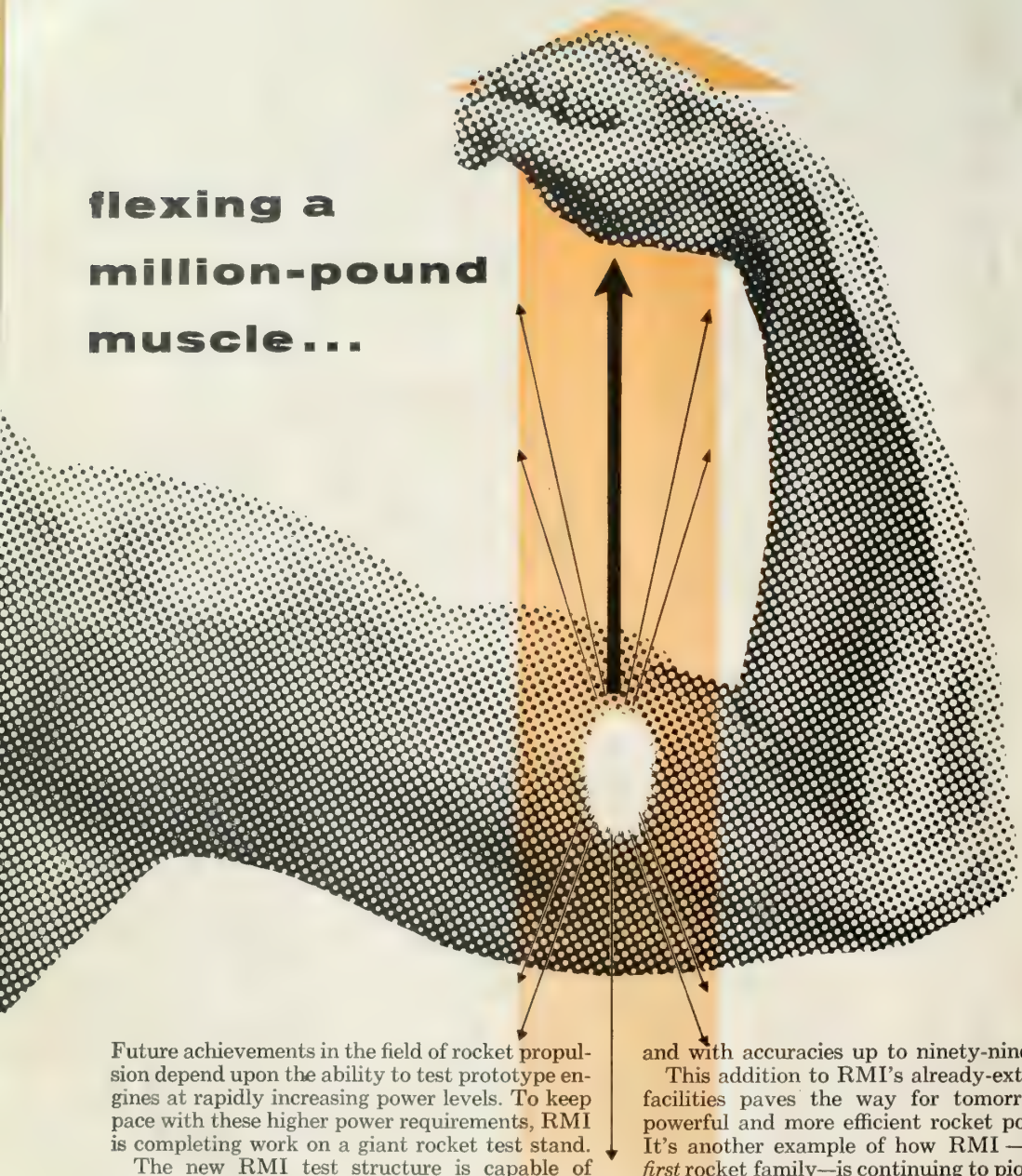
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Future achievements in the field of rocket propulsion depend upon the ability to test prototype engines at rapidly increasing power levels. To keep pace with these higher power requirements, RMI is completing work on a giant rocket test stand.

The new RMI test structure is capable of testing rocket engines in the million-pound thrust class. Its massive rotating system provides firing attitudes from vertically downward to 45 degrees above horizontal. The control center contains a maze of instruments that continuously record separate events occurring, within the engine, at intervals ranging from one-tenth of a second to less than one millisecond . . . and with accuracies up to ninety-nine per cent.

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MISSILES AND ROCKETS

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